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U.S. Federal Power Commission

Report...uses of the American River, California

Washington

1927

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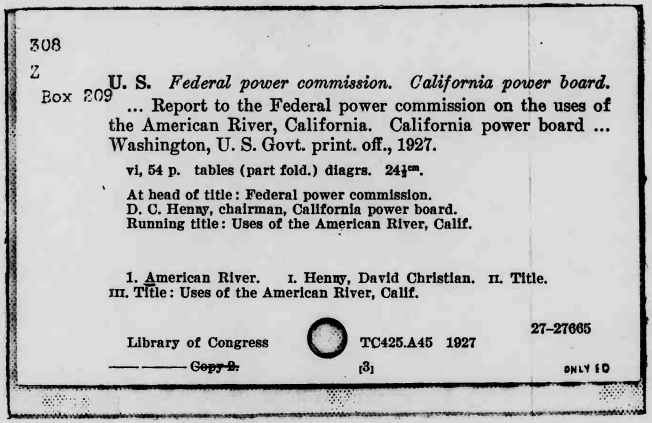

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U. S. *Federal power commission. California power board.* ... Report to the Federal power commission on the uses of the American River, California. California power board ... Washington, U. S. Govt. print. off., 1927.

vi, 54 p. tables (part fold.) diagrs. 24½cm.

At head of title: Federal power commission.
D. C. Henry, chairman, California power board.
Running title: Uses of the American River, Calif.

1. American River. I. Henry, David Christian. II. Title. III. Title: Uses of the American River, Calif.

Library of Congress TC425.A45 1927 27-27665
Copy 2. ONLY ED

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TECHNICAL MICROFORM DATA

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DATE FILMED: 4-29-97 INITIALS: PB

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REPORT TO THE FEDERAL POWER COMMISSION

ON THE

USES OF THE AMERICAN RIVER CALIFORNIA

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FEDERAL POWER COMMISSION

REPORT

TO THE

FEDERAL POWER COMMISSION

ON THE

USES OF THE AMERICAN RIVER, CALIFORNIA

CALIFORNIA POWER BOARD

D. C. HENNY.....Consulting Engineer, Bureau of Reclamation, *Chairman*
Department of the Interior

U. S. GRANT, 3d.....Major, Corps of Engineers, United States Army
War Department

E. W. KRAMER.....Hydraulic Engineer, Forest Service
Department of Agriculture

W. F. McCLURE.....State Engineer and Director of Public Works
State of California

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1927

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FEDERAL POWER COMMISSION

THE SECRETARY OF WAR, *Chairman*

THE SECRETARY OF THE INTERIOR THE SECRETARY OF AGRICULTURE

O. C. MERRILL, *Executive Secretary*

LETTER OF TRANSMITTAL

SAN FRANCISCO, *April 25, 1924.*

Mr. O. C. MERRILL,
Executive Secretary Federal Power Commission,
Washington, D. C.

SIR: The board of engineers appointed to study the American River in California in order to indicate the most beneficial uses which can be made of its water and especially to determine whether diversion from one to another tributary will be to the general public benefit submits its report herewith.

Board of Engineers.

D. C. HENNY, *Chairman.*
U. S. GRANT, 3d.
E. W. KRAMER.
W. F. MCCLURE, represented on the board by Mr. Paul Bailey.

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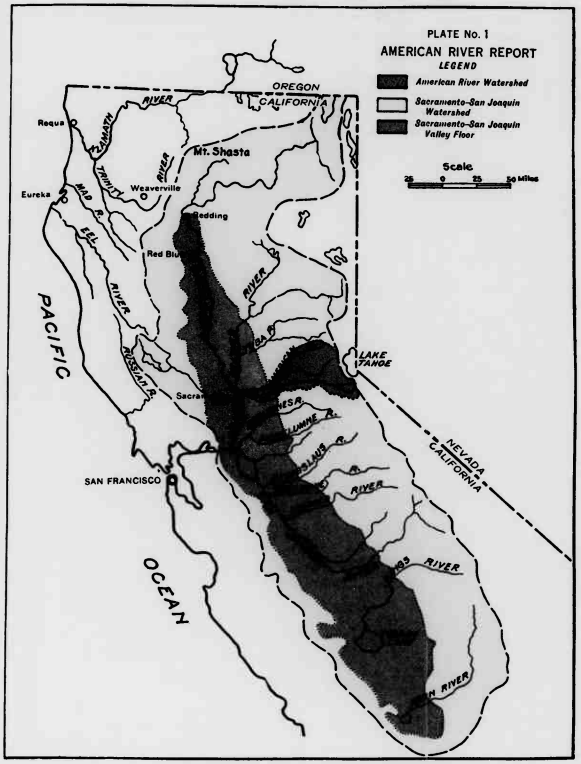

REPORT ON THE USES OF THE AMERICAN RIVER, CALIF.

INTRODUCTION

1. This board was appointed by the Federal Power Commission to make a general study of the American River in California with a view to comparing various schemes of utilization of water resources, and outlining such schemes as are best suited to the needs of power, irrigation, and domestic supply, bearing in mind the effect produced on interests dependent on the lower Sacramento River, notably navigation and island irrigation.

2. The board is made up of representatives of the departments of the Federal Government most vitally concerned, to which is joined a representative of the State of California within which the basin of the American River is situated.

3. The first meeting of the board was held in San Francisco on July 13, 1923. Since that time other meetings have been held by the full board or by some of its members in San Francisco, Sacramento, and Portland.

4. Field examinations were made by the full board from September 14 to September 21, 1923, supplemented by special investigations by members of the board at various times. During such examinations valuable assistance was rendered by city and company representatives interested in the work of the board, for which full appreciation is herewith expressed.

5. On November 26, 1923, a public hearing was held by the board at Sacramento, where full opportunity to submit their views was afforded to applicants for temporary permits before the Federal Power Commission and protestants. This hearing was attended by representatives of the applicants: The American River Water & Power Co. and the city of Sacramento, the latter on behalf of the Sacramento utility district, and by representatives of the protestants: The Pacific Gas & Electric Co., the Western States Gas & Electric Co., the Truckee River Power Co., and the North Side Water Users' Association.

6. At the suggestion of the board briefs were subsequently prepared and presented by applicants and protestants, which, together with the verbatim report of the hearing, are sent herewith.[1]

[1] Not prin

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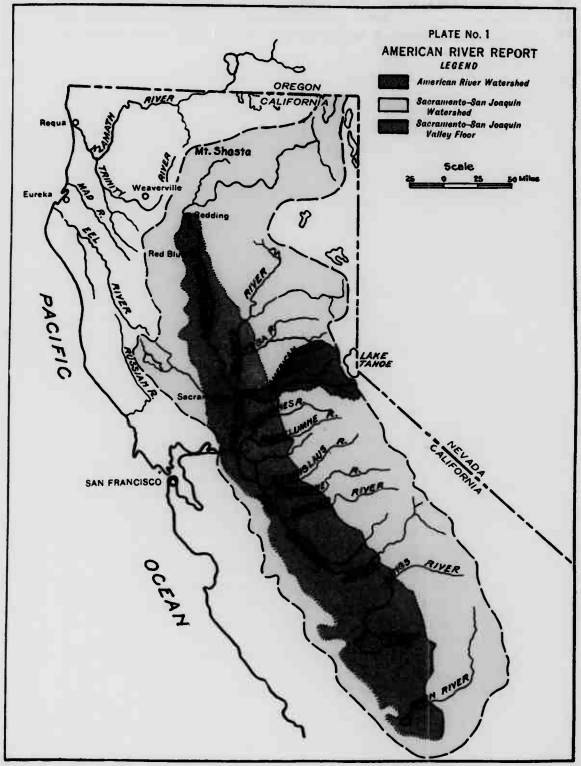

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7. The body of this report contains a discussion of alternate uses of American River water, together with conclusions and recommendations.[2] A description of the basin, a discussion of the power and irrigation possibilites, and other uses for the water will be found in Appendixes I to IV.

COMPARISON OF ALTERNATE USES

8. The American River system with its three main forks drains the mountainous area lying to the east and northeast of the city of Sacramento. Plate 1 shows its relation to the State of California. Plate 2 shows the watershed in greater detail. Appendix I contains a description of the main features of the shed.

9. The steep river gradients, descending about 6,000 feet in the upper 50 miles of the stream courses, favor economical power development, which is, however, hampered by the wide fluctuations of stream flow throughout the year, by the occurrence at intervals of unusually dry years, and by the paucity of storage facilities at high elevations to equalize the power flow. Appendix II deals with water supply available for power and with aggregate power and power costs.

10. In the ridge area within the basin, in the vicinity of Georgetown, climate, topographic conditions, and soil combine in providing excellent irrigation possibilities. The great depth to which glaciers and streams have eroded the western slope of the Sierra Nevada necessitates long and costly diversion canals. Past irrigation development has been slow and would have been slower still if it had not been facilitated by the use of ditches and pipe lines built for hydraulic mining. Irrigation possibilities above Folson are treated in detail in Appendix III.

11. The hydraulic mining industry, which in early days came to remarkable development in this and adjoining drainage areas, is no longer an important factor in the American River Basin. The deleterious effect on lower reaches of the stream resulted in Federal control of hydraulic mining. The cost of works for the retention of mine tailings has been one of the causes to lessen its importance, and as an industrial factor in the use of American River water, hydraulic mining need receive no consideration.

12. Flood control near and below the junction of the American and Sacramento Rivers is a highly important problem, as is shown in Appendix IV, a solution of which has already been provided by the flood-control project in the course of execution by the United States and the State of California, independent of the American River problem. Storage in the American River Basin might be used for flood control and thereby decrease the magnitude of the works of this flood-control project necessary for full protection. However,

[2] Recommendations not printed.

since this project is largely constructed and since the use of such storage for Sacramento Valley irrigation, as will be pointed out later, will produce very large economic benefits, greater than that of flood control which will, nevertheless, be incidentally benefited thereby, the reservation of storage possibilities on the American River for the special purpose of flood control is in the circumstances undesirable.

13. The feature of navigation acquires importance only below the mouth of the American River. It is pointed out in Appendix IV that while the total flow in the lower reaches of the stream will be reduced by diversion for irrigation made possible by large storage construction the return flow from irrigated lands will tend to maintain if not to increase the low-water flow. This same argument holds good as to the effect on the salt content of lower Sacramento River water so far as it may cause injury to island irrigators. For details on navigation, flood control, and industrial uses reference is made to Appendix IV.

14. Reviewing the general American River situation, it appears that no conflict as to alternative uses of water exists between navigation, protection of island irrigation against salt-water inflow, and flood control on the one hand, and power, irrigation, and domestic supply on the other. Between the latter three uses, however, there are possibilities of adjustment which require serious study in order to arrive at conclusions which promise to be of greatest benefit to the public.

15. Power, and to a large extent domestic supply, require a rather uniform flow, while irrigation calls for seasonal regulation. Natural river flow meets neither of these requirements. The flood period in the upper reaches generally extends from March to June, while lower down on the stream it begins from one to two months earlier. During this flood period about 80 per cent of the annual run-off is discharged, leaving only 20 per cent available during the remaining seven or eight months. The dry seasonal flow becomes very small in August, September, and October, the run-off during these three months being only 4 or 5 per cent of the yearly flow, or about one-fifth or one-sixth of the average, while for single months and weeks the flow becomes quite small. The September out-flow from the entire basin at times averages as low as 250 second-feet.

16. From the above it is apparent that for purposes requiring a steady flow as for power, or a regulated seasonal flow extending into the low run-off period as for irrigation, flow regulation becomes of the utmost importance.

17. It is on account of the relatively limited means of flow regulation in the upper part of the drainage area that conflict arises between different methods of utilizing the general resources for irrigation and power.

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18. The means of flow reinforcement in any one of the main or subsidiary forks of the American River consist of storage and of diverting water from one part of the watershed with or without storage through the intervening ridge to another part. The storage method is a distinct gain to the entire system; the diversion method is for the benefit of one fork of the system at the expense of another fork.

19. As the diversion method implies a far-reaching change of natural conditions besides large expense for mere transfer of water, it is evident that it can be justified only by some special advantage such as large increase of feasible power output or greatly decreased development cost through combination of water supplies.

20. In the consideration of the division of waters between interests of irrigation within the basin above Folsom and all other interests it was found that there are three main irrigable areas. The area north of the North Fork is irrigated largely from the Bear and Yuba Rivers and is therefore no factor in the present problem. The area to the south of the South Fork draws its supply partly from the Cosumnes and partly from the South Fork of the American and its tributaries. Since permits and rights to the use of storage facilities on the South Fork exclusive of Silver Creek have been granted, consideration of the needs of this area has been deemed outside the scope of this report.

21. There is, however, an important irrigable area situated on the Georgetown Ridge dependent for its supply upon parts of the stream system studied by this board which deserves serious attention. The soil and climate are excellent for horticulture and the production of other high-grade crops with a comparatively small consumption of irrigation water, as has been proven by the successful gradual conversion from brush and forest land to productive farms. The area available for expansion has been carefully studied and is estimated at 25,000 acres, of which about one-eighth is now irrigated.

22. The sources from which the irrigation supply for the Georgetown Ridge area can be feasibly drawn are quite circumbscribed and consist, in the order of nearness, of Pilot Creek, Little South Fork of the Rubicon, Gerle Creek, and finally the Rubicon River itself, all being part of the Rubicon system.

23. The maximum requirement at any one time for 25,000 acres is estimated at 208 second-feet, which is available in the above-mentioned streams only during a small part of the irrigation season. Storage requirements are estimated as follows:

	Acre-feet
Water requirements including ditch losses	50,000
Water available from direct stream flow	20,000
Water ultimately required from storage	30,000

24. Storage can be had in Loon Lake and on Gerle Creek below Loon Lake, the former having been partially developed and used. Full development of Loon Lake storage may be planned for power purposes alone, and its sole and unhampered use for power would be of great benefit to it. Moreover, water not used for irrigation in the foothills can be applied to Sacramento Valley lands after being used for power. This board holds, however, since the value of irrigation water in the foothills is relatively high, the Sacramento Valley can be irrigated from other sources, and the claim upon this water for local improvement has a decided element of fairness, that the greatest public benefit will result by providing for the full irrigation of the Georgetown Ridge in spite of the potential power loss which may result therefrom, estimated at 16,000 horsepower. It is believed, therefore, that any storage rights to be granted to power in the area of the Rubicon River above the mouth of the Little South Fork of the Rubicon should be made subject to certain obligations, compelling delivery of irrigation water in the amounts and at the time needed at favorable points for diverting into the ditch system and upon fair terms of compensation based on costs.

25. So far as this board is aware, the above opinion is concurred in by all public and private bodies interested in power development and irrigation. Such provision will remove the subject of protection of irrigation expansion from the field of conflict.

26. The water flowing from parts of the upper drainage shed where there is practically no habitation and where roads are scarce and unimproved is of excellent quality for domestic supply at the present time, and with prompt restrictions for its protection might be made to remain so in the future. The desirability of so restricting such a large area has not been considered by this board since it involves the comparative merits of other sources of domestic supply. However, these waters may be made available to near-by and even to distant cities in connection with power development and storage. At present the city of Sacramento is seriously considering this source for its domestic water supply.

27. Valley irrigation from the American River will undoubtedly become one of the most valuable economic uses of its water as soon as large storage works are constructed for which ample possibilities may exist on the lower reaches of the river system where grades are flat and conditions for dam sites are favorable. There is one site for large storage, to wit, the Coloma Reservoir site at river elevation of about 600 feet on the main stream of the South Fork which has a possible capacity of at least 300,000 acre-feet. The flat gradients and narrow gorges at corresponding elevations on the Middle and North Forks make it probable that ample storage may also be found at low elevations on these forks to regulate the flow so as to meet the

seasonal demands of irrigation on the floor of the Sacramento Valley. Such possible storage is all upstream from the Folsom Dam on the main American River, which would serve as the logical diversion point for distribution on the valley floor.

28. The total run-off of the American River as measured since 1904 has averaged over 3,000,000 acre-feet per year. In low years it has dropped to about 1,250,000 acre-feet. Economic storage will undoubtedly be insufficient to prevent large waste. If, however, storage can be found to regulate the outflow for irrigation use to a total of 1,000,000 acre-feet, the water supply, if economically used, may be sufficient for the irrigation of 400,000 acres. The storing of this water on the lower reaches of the stream does not interfere with any other use of the water, and, as was stated before, will incidentally tend to improve flood conditions and fresh-water supply for the islands below. The amount of water so far used for low foothill and valley irrigation is small by reason of low summer flow and the demands of the Folsom power plant, below which gravity irrigation is not feasible and resort must be had to pumping.

29. The subject of present and future possible power in the American River Basin is treated at length in Appendix II. Present power development in the basin affecting the general river problem is confined to the properties of the Western States Gas & Electric Co. and of the Pacific Gas & Electric Co. The first-named company utilizes the flow of the South Fork of the American River. It owns two power plants, the upper one being located near the mouth of Silver Creek and the lower one 10 miles further downstream. The Pacific Gas & Electric Co. owns a plant at Folsom, on the American River, a few miles below the mouth of the South Fork.

30. The Folsom plant of the Pacific Gas & Electric Co. operates under a low head (55 feet), and during some summer months the plant is shut down for part of each day by reason of insufficient flow. The State of California also has certain rights to power water from the Folsom diversion. Allowances have been made for the satisfaction of the power rights at this point as well as those of existing power plants on the South Fork, in the studies of available water for upper power development in Appendix II.

31. In the present report the study of future power development has been extended over the entire basin with the sole exception of the drainage area of the South Fork (exclusive of Silver Creek) from which the Western States Gas & Electric Co. draws its principal supply. In the area thus excluded certain permits have been granted,[3] and there is at the present time, so far as known to this

[3] The following licenses are referred to: No. 78, Western States Gas & Electric Co., covering its "American River plant"; No. 184, El Dorado Power Co. (subsidiary of Western States Gas & Electric Co.), covering the El Dorado plant and six storage reservoirs in the watershed of South Fork above the mouth of Silver Creek; and No. 396, city of Sacramento, small plant at city's vacation camp on upper South Fork.

board, no conflict of interests and no development for which applications are on file with your commission.

32. Water-supply and power studies are presented in Appendix II. They were based on the flow which was available during the period July 1, 1911, to January 31, 1914. This period is found to be the crucial one in the cycle 1903–1923. Water measurements during this period were taken only at a few points; flow at other points had to be estimated by relationship as to elevation, drainage areas, and proportionate flow during other periods.

33. All available information as to storage in the upper drainage area has been utilized and assumptions have been made as to reservoir capacities in connection with water supply available as follows:

	Acre-feet
In North Fork upper drainage area	0
In Middle Fork upper drainage area on main stream:	
1. French Meadows on Middle Fork	64,000
In Middle Fork upper drainage area on Rubicon watershed:	
2. Rock Pound and Buck Island Lakes in upper Rubicon watershed	24,000
3. Hell Hole on Rubicon River	32,000
4. Parsley Bar on Rubicon River	13,000
5. Loon Lake on Gerle Creek	47,000
6. Middle Gerle Creek	8,500
7. Upper Pilot Creek	5,600
In South Fork upper drainage area on Silver Creek watershed:	
8. Ice House on South Fork of Silver Creek	45,000
9. Union Valley on Silver Creek	165,000
Total	404,100

34. The above list of reservoirs does not include any storage sites in the upper South Fork Basin, which, as was stated above, was not included in the board's study. Nor does it not take into consideration possibilities of storage too low on the stream to be of special benefit for all-year power. Large amounts of power of a distinctly seasonal character would, however, become available below these reservoirs, which may ultimately have great value for irrigation pumping.

35. In the various schemes of general power development which have been worked out the same storage capacity has been assumed for each individual reservoir, although some variation of capacity may give slightly superior results. In some schemes some of the smaller reservoirs were omitted because they are too expensive in relation to the benefits derived.

36. The main difference in the various methods or general schemes of power development is not as to the use or nonuse of some of the reservoirs but lies in assumptions as to diversion from one to another portion of the drainage shed. It is on the question of diversion and the use of storage for the regulation of diversion that conflict exists,

since such diversion, while of great benefit to the stream which is thereby reinforced, is a serious injury to the stream from which the water is taken.

37. The presentation of these various schemes given in full in Appendix II shows that there is a gain in power if North Fork is diverted to Middle Fork instead of developing each stream independently, due to the regulation of the flow from the upper North Fork drainage diverted to French Meadows Reservoir on the Middle Fork. Therefore its water can be used effectively for power only if joined with Middle Fork water. The power which can be developed by such junction of waters is shown below.

Subscheme A

Middle Fork regulated by French Meadows Reservoir diverted to North Fork:	All-year horsepower
North Fork	78,000
Middle Fork	0
Total	78,000

Subscheme B

Upper North Fork water diverted to French Meadows Reservoir:	All-year horsepower
North Fork	0
Middle Fork	86,000
Total	86,000

38. From this it appears that subscheme B has an advantage over subscheme A in power developed. This is due to the lowest unit of the project (if the development is made along the Middle Fork) being located below the mouth of the Rubicon and being benefited by the Rubicon storage. It would, for this reason, have a smaller cost per horsepower developed. Furthermore, subscheme B can be developed by successive steps, the first of which need not include the construction of an expensive diversion tunnel, as would be the case with subscheme A. A rough estimate of cost of subscheme B has been introduced in subsequent summaries.

39. It should be understood that by all-year power is meant the average power that can be obtained during low-water periods like that of 1911–1913, which average is closely equivalent to power available for 90 per cent of the time for extended periods of years. Consequently, power machinery to approximately double this amount can be profitably installed if facilities are provided by forebay construction for meeting load variation.

40. Power development in the entire basin, exclusive of the South Fork, naturally divides itself into three groups of systems. One relates to the combination of the Middle Fork and North Fork, above

mentioned; the second to the Rubicon; and the third to the Silver Creek. As regards the latter the series of power plants utilizing its water extends below its mouth into the gorge of the lower South Fork, but does not utilize South Fork water, which has been considered assigned to the Western States Gas & Electric Co.'s development, not included in the board's study. Silver Creek water, considered as being covered by the rights of this company at low-water stages, was assumed to be released from the Silver Creek system for company use at the proper point on the South Fork and was excluded from water available to that system in its lower plant.

41. Four general schemes of power development have been studied with results set forth in the following tabulation in which reservoirs used in each scheme are numbered as per table in paragraph 33.

Scheme	Description. (For details see Appendix II)	Reservoirs	All-year horsepower	Total cost[1]	Credit from irrigation: Acres	Credit from irrigation: Amount	Net power cost[1]	Cost per all-year horsepower
I	Diversion North Fork to Middle Fork, diversion of 80.71 S. M.[2] upper Rubicon to Silver Creek:							
	North and Middle Fork	1	[3]80,000	$20,120,000	36,000	$720,000	$19,400,000	$243
	Rubicon	3, 4	37,000	7,960,000	26,000	520,000	7,440,000	201
	Silver Creek	2, 5, 6, 8, 9	136,000	32,099,000	87,000	1,740,000	30,359,000	223
			253,000	60,179,000	149,000	2,980,000	57,199,000	226
II	Diversion North Fork to Middle Fork:							
	North and Middle Fork	1	86,000	21,259,000	36,000	720,000	20,530,000	239
	Rubicon	2–7	99,000	20,509,000	77,000	1,540,000	18,969,000	192
	Silver Creek	8, 9	79,000	19,250,000	38,000	760,000	18,490,000	234
			264,000	61,009,000	151,000	3,020,000	57,989,000	220
III	No diversion:							
	North Fork	1	0					
	Middle Fork	1	45,000					
	Rubicon	2–7	99,000					
	Silver Creek	8, 9	79,000	Not computed.				
			223,000					
IV	Diversion North Fork to Middle Fork, diversion 93.5 S. M.[2] upper Rubicon to Middle Fork:							
	Middle Fork	1	114,000					
	Rubicon		0					
	Silver Creek	8, 9	79,000	Not computed.				
			193,000					

[1] Costs include installation of approximately double all-year capacity but exclude transmission lines and substations.
[2] S. M. = second-feet months.
[3] Subscheme B less upper Rubicon water in lower unit.

42. In the preceding tabulation credits to irrigation supply both to Georgetown Ridge lands and to lower valley lands have been arbitrarily based on an estimate of $20 per acre for the mere purpose of present comparison and without the more accurate determination

which should precede actual contract with Georgetown or other lands. Under the heading "Silver Creek" credits are likewise based upon simple irrigation value, although this project, as will be shown later, is planned to supply domestic water to Sacramento.

43. The aggregate power of Scheme III and especially Scheme IV is materially below that of Schemes I and II. Cost estimates are therefore presented for Schemes I and II only. Comparison of aggregate power shows that diversion of upper Rubicon water to the Middle Fork, even with the benefit of maximum practicable diversion from the Rubicon drainage shed, as in Scheme IV, is inadvisable. From this it may be concluded that diversion from a smaller part of this shed to the Middle Fork, as has been contemplated, is also inadvisable. This disposes of one of the minor items of the American River problem.

44. The major item of the problem is the question whether the water from the upper Rubicon, diminished by the requirements of Georgetown Ridge irrigation, should be permitted to be diverted to Silver Creek. The effect of such diversion becomes fully apparent by a comparison of Schemes I and II, the former scheme being based on an approval and the latter on a denial of such permit.

45. The amount of power developed by the Silver Creek project would be increased from 79,000 to 136,000 all-year horsepower by inclusion of the Rubicon waters, and its ultimate unit cost for complete development would be somewhat cheapened. Also, the dependable supply of water which would become available for diversion for any purpose at the tailrace of the lowest power plant would be increased from 268 to 427 second-feet, as shown in Tables 10 and 11, Appendix II.

46. However, the total potential power which can be developed in the basin, exclusive of South Fork power, would be reduced from 264,000 to 253,000 horsepower by the diversion of the Rubicon waters into Silver Creek. Also, the average horsepower cost would be slightly increased thereby. The differences are relatively not very great, yet Scheme II, as a whole, would permit not only the ultimate development of an extra 11,000 horsepower, but since it would make possible such additional development at an additional cost of only $790,000, or $72 per horsepower, it would imply an ultimate saving of over $1,600,000 of invested capital.

47. The opinion was expressed that diversion from one main portion of the drainage shed to another can not be looked upon with favor unless some decided advantage that would result therefrom is apparent. The effect of such diversion upon general public interests, while not specially great, appears to be injurious. Without diversion both the Silver Creek and the Rubicon by themselves offer opportunities for power development sufficiently large to be attractive and to

justify construction and maintenance of costly transmission lines. With diversion of the Rubicon into Silver Creek, the possibilities on Silver Creek are enhanced, but those on the Rubicon are so seriously reduced as to probably result in long-deferred development.

48. The foregoing estimates of power costs, which do not include the costs of transmission lines, do not reflect a true comparison of the merits of the several schemes as projects to supply a given territory, but rather indicate the relation of these schemes to the ultimate development, under which the sum total cost of transmission lines to all projects would be practically the same, whichever scheme were followed. Likewise, the comparison of the data of the several schemes does not reflect their respective merits as projects for supplying domestic or irrigation water to a given territory in conjunction with power developments, since they do not include the costs of conduits to and from the lowest power house to the points of use.

49. The separation of the Rubicon waters from the Silver Creek project proposed by the city of Sacramento does not reduce the available power and water below an amount that should meet its demands for a reasonably extended future.

50. As to power, it is understood that the peak demand in Sacramento at present is about 20,000 horsepower. The Silver Creek possibilities without Rubicon water are 79,000 horsepower. With an installation of about double this amount this smaller project can take care of a peak demand nearly eight times that of the present. It may well be concluded that the abundant provisions thus made for meeting the growing power demand of Sacramento and vicinity are sufficient.

51. In regard to water supply for both domestic and irrigation use, city authorities have estimated that in 1950 Sacramento may have a population of 400,000 as against 90,000 at present and may at that time require a domestic supply of 150 second-feet. Thus with a total supply available of 268 second-feet there would still remain on hand a balance of 118 second-feet continuous flow for the irrigation of those parts of the utility district where agriculture will not have been displaced by urban and suburban development. This balance, if reregulated by lower storage after use for power, will be sufficient for the irrigation of 34,000 acres, an irrigable area much greater than that which will be in the present utility district at the time the population is quadrupled.

52. For these reasons a tying up of the water resources of the American River by granting permit for the diversion of the Rubicon waters into Silver Creek is not thought to be justified.

53. The estimates of water supply and development costs used in this analysis, while believed to be as accurate as may be expected

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with available data, are necessarily subject to possible modifications with the collection of more complete data on stream flow and the prosecution of more complete surveys. The water supply available at various points on the stream where no direct measurements have been made have had to be approximated by a process of deduction from data available, while the estimates of cost had to be based in most cases on scant data in the absence of surveys. The unit prices used are based on costs of recently constructed projects, and the final costs include 30 per cent for contingencies and overhead charges. It was not practicable for this board to deal with the gradual investment and interest accumulation during the earlier years of development of each project, which will have an influence on total cost. However, the results are believed to be sufficiently approximate to warrant the arguments above made and the conclusions which follow.

54. It should be further stated that in the estimates of available water supply and of cost, vested rights have been assumed to be fully protected, and where acquisition of properties for any one scheme was found to be necessary the estimates include proper compensation therefor.

CONCLUSIONS

55. On the basis of the above arguments and estimates, it is concluded:

a. That navigation and salt-water conditions in the Sacramento River below Sacramento will not be injuriously affected by any uses of the American River water now anticipated, including domestic water supply, irrigation, and power.

b. That storage facilities in the American River Basin should be dedicated to irrigation and power primarily, since their economic value for these purposes is too great to justify their development solely for flood control.

c. That the fullest practicable irrigation of the cultivable lands of the American River Basin is in the interest of the public and requires that any power or irrigation projects developing upper storage reservoirs in the Rubicon drainage area under Federal power license should be obligated to supply at reservoirs shortage in irrigation water for approximately 25,000 acres on the Georgetown Ridge at a price based on investment and cost of service and not on value of power lost by supplying this irrigation need.

d. That until investigations show that large storage for valley irrigation can not be feasibly developed on the lower reaches of the North and Middle Forks below river elevation 1,150 it is inadvisable to permit power development which would interfere with irrigation storage below this elevation.

e. That the Coloma Reservoir has sufficient capacity and is so located that it can regulate for the benefit of irrigation almost the entire flow of the South Fork of the American River below power developments. Its primary value is for irrigation storage.

f. That the Folsom Dam site admits raising the dam to a considerable additional height, and that this site is located at the logical point for diverting American River water for all lower gravity irrigation.

g. That the potential power of the North and Middle Forks of the American River can be best developed by the diversion of the upper North Fork drainage to French Meadows Reservoir on the Middle Fork.

h. That the diversion of Rubicon water to the Middle Fork would be wasteful of power.[4]

i. That the diversion of Rubicon water to Silver Creek would prevent maximum power utilization and would tend to increase the total power cost.

j. That the municipal power, domestic water supply, and irrigation requirements of the city of Sacramento and the Sacramento Municipal Utility District for a reasonably extended future can be satisfactorily supplied from Silver Creek without Rubicon diversion.

[4] In the light of data obtained from more detailed surveys it may be found that this conclusion needs modification in so far as it relates to diversion from a part only of the upper watershed.—EDITOR.

APPENDIX I

GENERAL DESCRIPTION OF THE AMERICAN RIVER BASIN

By E. W. KRAMER, *Hydraulic Engineer, United States Forest Service*

1. The American River Basin, 1,919 square miles in area, extends northeasterly from Sacramento, where the stream joins the Sacramento River, to the main Sierra divide, a distance of approximately 80 miles. The maximum width of the shed in a north and south direction is about 40 miles. It is crossed in an east and west direction by the Ogden branch of the Southern Pacific Railway and two transcontinental highways.

2. The stream proper is formed by the junction of its North and South Forks 29 miles above its mouth. The Middle Fork joins the North Fork at a point 18 miles farther upstream. These three forks are the main tributaries, the watershed of each extending back to the crest of the Sierras.

3. The Middle Fork has a large tributary, the Rubicon, joining it 25 miles above its junction with the North Fork, its watershed also extending back to the main Sierra divide. The principal tributaries of the South Fork are Silver Fork, Silver Creek, and Weber Creek. The first shares the headwater drainage along the Sierra crest about equally with the South Fork proper. The sheds of the other two do not extend to the main divide.

4. For the purpose of run-off, power, and irrigation studies the surface of the basin may be divided into four general areas: (1) The upper area, including the high granitic peaks, domes, and glaciated basins extending to the west of the main Sierra divide for a distance of from 8 to 10 miles; (2) the ridge area, including the long ridges and canyons extending west from the upper area for a distance of about 35 miles; (3) the foothill area, extending west from the breaking up of the ridges for a distance of about 15 miles; and (4) the valley area forming part of the Sacramento Valley and lying between the foothills and the Sacramento River.

5. The upper area varies in elevation from about 5,000 feet along the streams to about 8,500 to 10,500 feet along the Sierra divide. It includes the headwaters of the North, Middle, and South Forks of the American River, the Rubicon River, and the Silver Fork of the South Fork, but not Silver Creek. The precipitation varies from 50 to 60 inches. A very large percentage of it is in the form of snow; also a very high percentage runs off to the streams on account of the steepness of the slopes and the thinness of the soil. Lying within this area are the French Meadows reservoir site on the Middle Fork; the Rock Bound, Buck Island, Loon Lake, and Hell Hole reservoir sites on the Rubicon, and the Medley Lake, Echo Lake, Twin Lakes, and Silver Lake sites on the South Fork. Except for tourists and campers, it is uninhabited.

6. The second or ridge area is cut by the deep canyons of the three main forks and the canyon of the Rubicon River. The slopes of these canyons and the ridges lying between them are well covered with soil and timber. The elevation of the ridges varies from about 5,000 feet at their east ends to about

2,000 feet at their west ends where they begin to break off into foothills. In general, the streams between these ridges are from 1,000 to 2,000 feet lower than the crests of the ridges. Since the forks are usually about 10 miles apart, this portion of the shed can be pictured as a series of high ridges extending east and west.

7. This ridge area contains the towns of Placerville, Colfax, Georgetown, and other smaller ones. Except in the vicinity of the towns or where irrigated, it is very sparsely settled. Below elevation 3,500 feet there is considerable cultivation, but above this elevation the only important industries are mining, lumbering, and stock grazing. The Parsley Bar reservoir site on the Rubicon, the two large reservoir sites on Silver Creek, namely, Union and Ice House, all the Silver Creek drainage and a reservoir site on Weber Creek, all lie within this ridge area. The cultivable areas lie here and there along the ridges and where irrigated are very productive. Deciduous California fruits are raised on a commercial scale. The precipitation varies from 20 to 60 inches, according to elevation. Below elevation 3,500 irrigation is required to obtain adequate agricultural returns.

8. The American slope of the ridge between the North Fork and Bear River is irrigated to the extent of approximately 26,000 acres from the South Yuba and Bear River system of the Pacific Gas & Electric Co., which system has a capacity to irrigate approximately 15,000 acres additional.

9. The ridge between the Middle Fork and North Fork is practically unirrigated. It has considerable cultivable land below elevation 3,500 in the neighborhood of Succor Flat which would logically be irrigated from the North Fork or the North Fork of Middle Fork if the expense of getting the streams to the lands was not prohibitive on account of the length of ditch, lack of storage, and, in case of the North Fork, precipitous canyon sides.

10. The ridge between the Rubicon River and the Middle Fork has very steep slopes and practically no cultivable land.

11. The ridge between the Rubicon, the Middle Fork, and North Fork on the one side, and the South Fork on the other, known as the Georgetown Ridge, has about 25,000 irrigable acres lying below elevation 3,500 feet, about 3,000 of which are now irrigated by a system built by the Truckee River Power & Water Co., which includes storage in Loon Lake Reservoir.

12. The ridge lying between the South Fork of the American River and the Cosumnes River contains the town of Placerville and is crossed by the Lincoln Highway. Strung along the highway from Placerville to the Sierra divide are numerous small settlements, tourist hotels, and camps. There is a large cultivable area on this ridge of about 30,000 acres, of which about 5,000 acres are now irrigated from the South Fork of American River, Weber Creek, a tributary of the South Fork, and the Cosumnes River. There are two main diversions from the South Fork, the uppermost of which is the Eldorado ditch of the El Dorado Power Co., a subsidiary company of the Western States Gas & Electric Co., which carries water jointly for power and irrigation, a maximum of about 40 second-feet being devoted to the latter purpose. The lower diversion is the American River plant of the Western States Gas & Electric Co. It is located on the South Fork of American River in this ridge area. It also supplies some water for irrigation. A more detailed description of these plants is given in Appendix II.

13. Lying to the west of the ridge area for an average distance of 15 miles is the foothill area. The elevation ranges in general from 1,500 feet at the east side to about 200 feet at the west. Where not cleared, these foothills are covered with scattering oak and brush and in some places by a fairly dense stand of conifers. This foothill region contains the towns of Auburn, Folsom, Newcastle, and other smaller towns. It also contains the large Coloma Reservoir site on

the South Fork. The foothill land is partly farmed, partly in pasture, and partly in brush and timber. The farmed area produces nearly all of the deciduous California fruits and is well adapted to the production of Bartlett pears and Tokay grapes. The precipitation varies from 16 to 30 inches annually. Irrigation is necessary for production on a commercial scale, but it is expensive on account of the cost of the construction and upkeep of irrigation ditches, both main canals and laterals. This is due to the irrigable tracts not being contiguous and to the great length of supply conduits needed to get the water from the deep canyons to the high ridges.

14. The Middle Fork joins the North Fork just to the east of the foothill area; thence the North Fork traverses this area to its junction with the South Fork, forming the American River proper at a point which is still in the foothill area. The stream leaves the foothills approximately at Folsom, about 2 miles below the mouth of the South Fork. The North Fork ditch which diverts from the North Fork of the American River near the eastern edge of this area, has a capacity of 60 second-feet and irrigates 10,000 acres partly in the foothills and partly in the Sacramento Valley north of the American River.

15. West of the foothills lies the Sacramento Valley, which can be described in this vicinity as a slightly rolling plain having a general slope toward the west from about elevation 200 feet on the east to the Sacramento River on the west, an average distance of 12 miles. This valley area west of the American River shed and between it and the Sacramento River can be said to have a width north and south of about 20 miles. It is not all tributary to the American River, some of it being drained by creeks which flow directly into the Sacramento. These creeks, however, have no mountain drainage area and therefore this portion of the Sacramento Valley can be classed in a general way with the American River Basin in so far as irrigation problems are concerned. Lying in this area are the towns of Roseville, Lincoln, Orange Vale, and Sacramento. The chief industry is farming. All of the California fruits do well and are produced on a commercial scale. A very large part of this area is still unirrigated. The annual precipitation is about 16 inches. Irrigation is required except for a few crops such as grain. About 40,000 acres are irrigated either by pumping from the American River, from wells, or from the Sacramento River; or by gravity from small streams rising in the foothills. The major part of it, however, some 180,000 acres, is not irrigated and will most likely have to depend on the American River or some other Sierra stream for its irrigation supply. The Sacramento utility district and the proposed Roseville irrigation district lie entirely within this area.

16. A further description of this basin applying more particularly to power potentialities and developments is given in Appendix II.

APPENDIX II

DESCRIPTION OF POWER POSSIBILITIES IN AMERICAN RIVER BASIN

By E. W. KRAMER, *Hydraulic Engineer, United States Forest Service*

1. Each of the three main forks of the American River, with their principal tributaries, Rubicon River and Silver Creek, have power possibilities below a general elevation of about 5,000 or 6,000 feet, where the stream flow begins to be sufficient for diversion. This is due to the rapid fall of the streams, the fall per mile ranging around 200 feet for about the first 2,000-foot drop and grading down to 100 feet per mile for the next 2,500 feet. However, due to the great fluctuations in flow, storage above the power developments is required to make them economically feasible.

2. The Middle Fork, with its French Meadows site, and Silver Creek, with its Ice House and Union sites, are the only forks or tributaries which have sufficient storage capacity on their headwaters to completely equalize their stream flow. In the case of those two streams the storage capacity is sufficient to equalize the flow of one or two of the adjoining forks or tributaries which can be diverted to them. For this reason projects for diverting the Rubicon or the North Fork of the American to the Middle Fork and for bringing the Rubicon to Silver Creek have been proposed.

3. There is sufficient storage on the headwaters of the South Fork and the Rubicon to regulate their flow in part. Power developments on these streams are possible without diversion from other sheds.

4. There are no known storage sites of any size on the headwaters of the North Fork; hence it has been proposed to divert its upper waters to the Middle Fork or to divert a regulated flow from the Middle Fork to it.

5. In general it may be said that power developments on any of the forks of the American River will consist of mountain storage reservoirs near the headwaters; below these two or more high-head power drops developed by long conduits which will usually be partly in ditch and partly in tunnel; below this one or more medium-head power drops developed by high dams impounding water for irrigation with power house located immediately below dam and developing seasonal power incidentally to the primary purpose of irrigation.

6. It seems unlikely that it will be economical to develop year-long power on the main stream below the mouth of the South Fork when the power and irrigation possibilities of the shed are fully developed, on account of the likelihood and apparent desirability of diverting almost the entire flow of the American River for irrigation at the crest of the Folsom Dam.

7. The foundations for dams in what has been termed the upper area have in most cases been scoured clean by glacial action. Excavation for conduits within this area will be mostly in rock. On account of the altitude, it is believed that these conduits should be either in tunnel or covered ditches. The canyons in what has been termed the ridge area, although having steep slopes, are suitable for the construction of concrete-lined conduits which would be mostly in earth

except in the case of the North Fork. On this fork the canyon walls are precipitous for several hundred feet above the stream bed for most of the ridge area, where the excavation for conduit will be almost entirely in rock. However, after the conduit had obtained an elevation of a few hundred feet above the stream the excavation would be mostly in earth as in the case of other forks. Conduits in the foothills and valley area will be mostly in earth.

8. It is proposed in this appendix to describe in detail the power projects developing the power possibilities on the Middle Fork of the American River, the Rubicon River, and Silver Creek. A brief description of the developed and undeveloped sites on the South Fork will be given. It is believed and is shown later that the North Fork drainage above an elevation that allows its diversion to the French Meadows Reservoir on the Middle Fork should be diverted to the Middle Fork. Since this makes the development of any project on the North Fork below the point of diversion and above its junction with the Middle Fork infeasible under present economic conditions, no North Fork project will be described other than what is included in the description of the Middle Fork projects.

9. Estimates of power capacity are based on stream flow during the low-flow period from July 1, 1911, to December 31, 1913. This dry period includes the two consecutive years of lowest total flow that have occurred since records have been kept of the flow of the American River, which is from 1904 to the presen date. Bulletin No. 5 of the department of public works, State of California entitled "Flow in California Streams," at page 200, contains a table showing the estimated flow of the American River from 1871 to 1921, which is reproduced in this report as Table No. 1. This table shows that there was one two-year cycle of almost as low and two single-year periods of lower average flow than the period on which the writer's estimates are based. However, on account of the carry-over storage involved in the American River projects, it is believed that the average available power for this period represents the power capacity available 90 per cent of the time as well as this can usually be estimated where carry-over storage is involved.

TABLE No. 1.—*American River seasonal run-off data*[1]

(Drainage area, 1,919 square miles)

Season (begins Oct. 1)	Index of seasonal wetness Division J	Depth of run-off in inches	Run-off index	Estimated seasonal run-off in acre-feet (above main agricultural area)	Per cent distribution of seasonal run-off by months as shown by U. S. G. S. records
1871–72	120	41.2	132	4,215,600	January, 12.3.
1872–73	75	18.2	59	1,862,200	February, 11.6.
1873–74	100	30.1	97	3,079,800	March, 15.8.
1874–75	64	13.6	44	1,391,600	April, 17.
1875–76	124	43.5	140	4,450,900	May, 19.1.
1876–77	62	12.6	41	1,289,200	June, 12.8.
1877–78	93	26.6	85	2,721,700	July, 3.7.
1878–79	104	32.3	104	3,304,900	August, 0.9.
1879–80	125	44.0	141	4,502,100	September, 0.6.
1880–81	108	34.6	111	3,540,300	October, 0.8.
1881–82	103	31.9	102	3,264,000	November, 1.8.
1882–83	82	21.2	68	2,169,200	December, 3.6.
1883–84	118	40.1	129	4,103,000	
1884–85	73	17.4	56	1,780,400	
1885–86	115	38.3	123	3,918,900	
1886–87	75	18.2	59	1,862,200	
1887–88	68	15.4	50	1,575,700	

[1] From Bulletin No. 5, State of California, department of public works, division of engineering and irrigation.

TABLE No. 1.—*American River seasonal run-off data*—Continued.

Season (begins Oct. 1)	Index of seasonal wetness Division J	Depth of run-off in inches	Run-off index	Estimated seasonal run-off in acre-feet (above main agricultural area)	Per cent distribution of seasonal run-off by months as shown by U. S. G. S. records[1]
1888–89	76	18.6	60	1,903,200	
1889–90	169	75.5	243	7,725,200	
1890–91	77	19.0	61	1,944,100	
1891–92	90	25.1	81	2,568,200	
1892–93	123	43.0	138	4,399,800	
1893–94	104	32.3	104	3,304,900	
1894–95	128	46.3	149	4,737,400	
1895–96	114	37.7	121	3,857,500	
1896–97	110	35.5	114	3,632,400	Measured seasonal discharge in acre-feet at U. S. G. S. gauging station near Fairoaks
1897–98	59	11.6	37	1,186,900	
1898–99	86	25.1	74	2,393,600	
1899–1900	111	36.0	116	3,683,500	
1900–1901	112	36.3	117	3,714,200	
1901–2	100	30.1	97	3,079,800	
1902–3	99	29.7	95	3,038,900	
1903–4	137	51.3	165	5,249,000	
1904–5	100	20.0	64	[1]2,050,000	[2]1,955,000
1905–6	138	47.3	152	[1]4,535,900	4,763,100
1906–7	150	56.5	182	[1]5,792,800	5,710,100
1907–8	71	14.9	48	[1]1,526,600	1,453,600
1908–9	124	45.2	145	[1]4,622,500	4,549,200
1909–10	95	35.3	113	[1]3,614,500	3,541,500
1910–11	129	54.3	175	[1]5,555,300	5,480,500
1911–12	60	13.1	42	[1]1,336,100	1,264,000
1912–13	67	15.1	49	[1]1,541,800	1,433,800
1913–14	120	39.8	128	[1]4,072,100	3,951,000
1914–15	111	31.1	100	[1]3,179,800	3,060,900
1915–16	104	38.7	124	[1]3,964,600	3,847,900
1916–17	89	28.8	93	[1]2,948,300	2,831,800
1917–18	67	15.1	49	[1]1,541,100	1,420,400
1918–19	91	22.1	71	[1]2,265,800	2,154,900
1919–20	70	14.7	47	[1]1,501,600	1,391,300
1920–21	110	32.6	105	[1]3,336,800	3,223,080

SUMMARY OF ESTIMATED RUN-OFF

	Acre-feet	Depth in inches	Acre-feet per square mile	Season
Mean seasonal	3,181,900	31.1	1,658	
Maximum seasonal	7,725,200	75.5	4,026	1889–90
Minimum seasonal	1,186,900	11.6	618	1897–98
Mean during July	117,700	1.2	61	
Maximum during July	392,500	3.8	205	1905–06
Minimum during July	22,800	.2	12	1918–19
Mean during August	28,600	.3	15	
Maximum during August	92,800	.9	48	1906–7
Minimum during August	9,500	.1	5	1917–18

[1] Measured run-off adjusted for diversions as follows: Towle Canal (Pacific Gas & Electric Co. records); North Fork ditch, Nigger Hill ditch, El Dorado ditch, Pilot Creek ditch, Alder Creek pumping plant (Pacific Gas & Electric Co. and Natomas Mutual Water Co. records).
[2] Partial record, Nov. 4 to Sept. 30.

10. Records have been kept since November, 1904, by the Water Resources Branch of the United States Geological Survey of the flow of the American River at the Fairoaks gauging station, which is below all the forks. On the North, Middle, and South Forks at stations near their mouths the United States Geological Survey has also kept records which begin in the fall of 1911, and in the case of the first two extend to the present date. The South Fork station was discontinued in 1920. These four stations are the only ones in the American River Basin where continuous records were kept over any period longer than five years. Fortunately, however, stream-flow records were kept at a number of points in the Rubicon River drainage for a period which in most cases covers the critical

period on which estimates in this report are based. The records on the Rubicon drainage referred to were kept at the following points and for the following periods:

Rubicon River at Rubicon Springs	1910–1914
Rubicon River near Quintette	1909–1914
Little Rubicon River near Rubicon Springs	1910–1911
Little South Fork of Rubicon River at sawmill near Quintette	1910–1914
Little South Fork of Rubicon River below Gerle, near Quintette	1910–1914
Little South Fork of Rubicon River at mouth, near Quintette	1909–1911
Gerle Creek near Rubicon Springs	1910–1914
Little South Fork ditch at sawmill near Quintette	1910–1913
Pilot Creek near Quintette	1910–1914
Pilot Creek ditch near Quintette	1910–1914

The points of storage or diversion on the Rubicon drainage of interest in this report are either at or near the above gauging stations; it is believed, therefore, that the stream flow and power estimates in regard to the Rubicon projects in this report are reliable.

Unfortunately, on the other hand, estimates of the power capacities of the Silver Creek and Middle Fork developments necessarily had to be made from stream-flow estimates based on the distribution of the stream flow recorded at the lower gauging stations, over the watershed above, in accordance with the altitude, rainfall, and short run-off records available, which run-off records cover a period from December 23, 1921, to September 30, 1923, on Silver Creek and a short period in 1906–7 on the South Fork near Kyburz, Calif. The Rubicon records were also given consideration in estimating the run-off from the upper North and Middle Fork drainage areas.

11. Cost estimates follow each description of project. Transmission lines are not included. These estimates are based on a fair knowledge of the topography and on unit costs per cubic yard for dams in most cases, per unit of length of tunnels and open conduits, per pound of steel in penstocks, per horsepower of installation for power houses and machinery, and on lump-sum estimates for forebays and some miscellaneous items. No exact data on cubic yards of excavation, details of structures, or exact location of conduits were available. The cost of road improvement was included in cost of structures. These estimates must be regarded as of a preliminary nature, but they are believed to be sufficiently accurate to give a general idea of the feasibility of the projects.

MIDDLE FORK DEVELOPMENTS

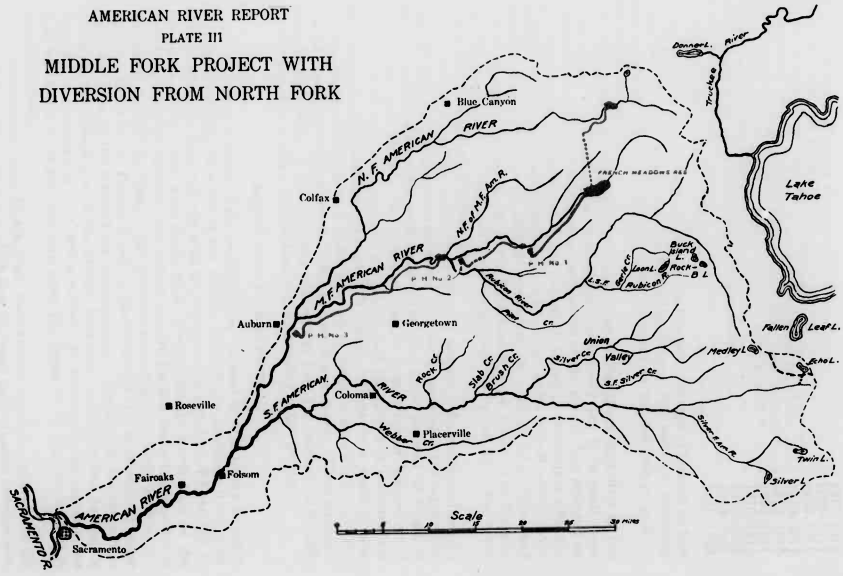
12. The term "Middle Fork developments" is used in this report to mean projects developing all power on the Middle Fork of the American River from French Meadows Reservoir site with its proposed crest elevation of 5,140 feet to the intake of the North Fork ditch, which diverts from the North Fork of the American River at elevation 480 feet at a point 4 miles below the junction of the North and Middle Forks. The diversion from either the North Fork or the Rubicon River to the French Meadows Reservoir will also be considered under the description of the Middle Fork developments. The French Meadows Reservoir on the headwaters of the Middle Fork may be constructed to have a capacity of from 64,000 to 90,000 acre-feet. In this report the capacity has been considered as 64,000 acre-feet, since this seems to be the amount that is certainly feasible.

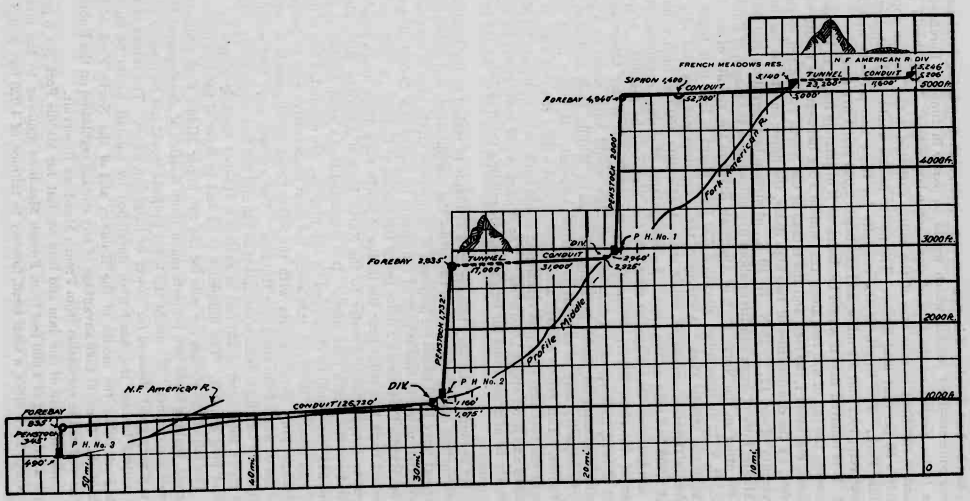
13. The distance along Middle Fork from French Meadows Reservoir to the intake of the North Fork ditch, which fixes the lower limit of power development, is approximately 50 miles. The distance to the mouth of Rubicon is 21 miles. It is thought that the potential power in the Middle Fork between French Meadows, elevation 5,140 feet, and the mouth of the Rubicon, elevation 1,150

AMERICAN RIVER REPORT

PLATE III

MIDDLE FORK PROJECT WITH DIVERSION FROM NORTH FORK





feet, can be best developed in two power projects, each drop being developed by a long concrete-lined conduit which would be partly in tunnel. Forebays will have to be located on the tops of small secondary ridges. They should have capacities sufficient to take care of the hourly variation in the load on approximately a 50 per cent load factor. The power houses would be located on the Middle Fork. The length of the conduits for these two projects would be, respectively, 10.2 and 9.1 miles, and the heads 2,000 and 1,675 feet.

14. It is believed that it would be desirable, if ultimately found to be feasible, to develop the fall of 670 feet along the Middle Fork between the mouth of the Rubicon, elevation 1,150 feet, and the intake of the North Fork ditch, elevation 480 feet, by the construction of two high dams, the upper one to be located in the vicinity of sec. 12, T. 13 N., R. 10 E., at stream-bed elevation 900 feet on the Middle Fork of American River about 6½ miles below the mouth of Rubicon, and the other on the North Fork of American River in the vicinity of sec. 1, T. 12 N., R. 8 E., at stream-bed elevation 530 feet, about a half mile below the mouth of the Middle Fork. A survey of the lower dam site was filed with the California Débris Commission, which shows that a dam 350 feet high would be about 1,300 feet long on the crest. An examination of surface conditions at the dam site indicates that a dam at least 300 feet high will be feasible. Maps of survey of American River, accompanying the California Water Commission's report of 1912, indicate that a dam 350 feet high would back water to a point 15 miles upstream on North Fork and 18 miles on Middle Fork and that the reservoir capacity may be as great as 400,000 acre-feet. It would flood about 4,000 acres. This report of 1912 also indicates that a dam 250 feet high at the upper of the two dam sites just mentioned would back water upstream for about 6½ miles and flood about 1,000 acres. The storage in the lower reservoir would ultimately be of great value for irrigation, reregulating the flow below the power developments.

15. On account of the very meager data available in regard to the feasibility of constructing high dams at these two sities, the computations and estimates in this report have been based for purposes of comparison on the plan of developing the potential power in this stretch of the stream by means of a 75-foot diversion dam on Middle Fork about 2 miles below the mouth of Rubicon, a long conduit on the left bank to a point near the intake of North Fork ditch, and a penstock and power house returning water to the North Fork of American River above the intake of the North Fork ditch. It is estimated that a head, forebay to tailrace, of 345 feet would be developed by this project. On account of loss of head in the long conduit involved, this seems the most conservative way to compare the Middle Fork developments with the Silver Creek developments in regard to the use of water from the upper Rubicon. The average head that would be developed by two high dams is estimated as 230 and 200 feet, respectively, which would give a total head of 430 feet as against a 345-foot head developed by one dam and long conduit. The difference is 85 feet in favor of the two dams.

16. The fall of the stream per mile for the two upper Middle Fork projects is very great, making these two projects much more feasible of development than the lower one or ones. No doubt the lower projects would not be feasible until there is a very great demand for power or irrigation water. The intake of the lower project in case the head were developed by conduit would be on the Middle Fork below the mouth of the Rubicon and of the North Fork of the Middle Fork. It could take advantage of any storage regulation on the Rubicon River as well as the regulation from French Meadows Reservoir.

17. Under the plan of one dam and long conduit for Middle Fork No. 3 project, with a total fall of 4,660 feet from French Meadows spillway to the intake of the North Fork ditch, a total head, forebay to tailrace, of 4,020 feet would be developed in the three Middle Fork projects. The remaining 640 feet would be lost in the grade of the conduits and in the drawdown in reservoirs.

18. The diversion of 43 square miles of the North Fork drainage to French Meadows Reservoir would be accomplished by the construction of a diversion dam about 40 feet high on North Fork and 6½ miles of conduit, of which 2 miles would be concrete lined and closed and the remainder in tunnel. This diversion would greatly increase the feasibility and lessen the unit costs of the Middle Fork project, as will be shown later.

19. There would be a loss in total power if the North and Middle Forks were each developed independent of the other instead of by the diversion of the upper North Fork to the Middle Fork. The point of proposed diversion of North Fork, elevation 5,246 feet, to French Meadows is about 61 miles above the junction with the Middle Fork and 46 miles above elevation 880 feet, which may be the elevation of ultimate irrigation storage on the North and Middle Forks, as before described. During the critical period, July, 1911, to December, 1913, used in estimating the 90 per cent time power for the various projects on the American River, the North Fork of American River at Colfax had a mean monthly flow of 70 second-feet or less for five months, the lowest being 33 second-feet. For the purpose of comparing the power that could be developed on North and Middle Forks without diversion from one to the other to the power that could be developed by the diversion of upper North Fork to French Meadows it is believed that the flow of North Fork for the section of the stream between elevation 5,246 and 880 can be taken as 70 second-feet. This is a liberal allowance, since the Colfax gauge is near the lower end of the drop. Assuming no considerable storage on upper North Fork, and even that it would be feasible to develop the entire drop of 4,366 feet from elevation 5,246 to 880 feet, the power in this stretch of the stream would be 24,000 horsepower.

Computations in Table No. 5 indicate that an average flow of 90 second-feet could be diverted from upper North Fork and equalized in the French Meadows Reservoir with a 300 second-foot capacity tunnel. The Middle Fork projects No. 1 and No. 2 would have a combined head, forebay to tailrace, of 3,675 feet. No. 3 project, if a 250-foot dam were built, would develop an average head of 230 feet, making the total head 3,905 feet. The 90 second-feet through this drop will develop 28,000 horsepower. It is therefore evident that there will be a gain of at least 4,000 horsepower by diverting upper North Fork to French Meadows instead of developing it along the North Fork. The alternative of developing projects along the North Fork will therefore be dropped from further consideration.

20. Diverting upper North Fork to French Meadows on Middle Fork and developing power along the Middle Fork has the advantage of allowing a progressive development, since the French Meadows Reservoir and one or more of the power projects could in this case be built first, leaving the expense of diversion tunnel from North Fork to French Meadows to the last, whereas if Middle Fork were diverted to North Fork this tunnel, as well as French Meadows Dam, would have to be built first on account of small utilized flow, due to lack of storage on North Fork. Also, as will be shown later, there is a small loss in total power if upper Middle Fork is diverted to North Fork instead of upper North Fork being diverted to Middle Fork, due largely to the Middle Fork No. 3 project being benefited by the storage regulation on the Rubicon.

21. There is also the possibility of diverting 93.5 square miles of the Rubicon drainage at elevation 5,260 feet to French Meadows by the construction of a diversion dam 40 feet high on the Rubicon and a conduit 8 miles long, of which 1 mile would be concrete lined and covered and the remainder in tunnel. This diversion from the Rubicon to French Meadows is incompatible with economical construction of the Rubicon projects or the diversion of the upper Rubicon to

Silver Creek. Tables and summaries which follow indicate a loss of power on the Rubicon caused by this diversion greater than the corresponding gain in power on the Middle Fork.

22. A study of the power capacities of the Middle Fork developments has been made under the following assumptions:

	Horsepower
(1) With no diversion to French Meadows, either from North Fork or Rubicon, and no diversion from Rubicon to Silver Creek, and the effect of Rubicon storage on Middle Fork project No. 3 not considered: The power capacity available 90 per cent of the time was estimated under these conditions to be (See Table No. 2.)	45,000
(2) With diversion of 93.5 square miles of upper Rubicon drainage to French Meadows, no diversion from North Fork and no storage developed on Rubicon: The power capacity available 90 per cent of the time was estimated under these conditions to be (See Table No. 4.)	114,000
(3) With diversion of 43 square miles of North Fork drainage to French Meadows, no diversion from Rubicon to French Meadows, and no diversion from Rubicon to Silver Creek, and with the effect of Rubicon storage on Middle Fork No. 3 project considered: The power capacity available 90 per cent of the time was estimated under these conditions to be (See Table No. 6.)	86,000
(4) With diversion of 43 square miles of North Fork to French Meadows, no diversion of upper Rubicon to French Meadows, upper Rubicon water diverted to Silver Creek, and with the effect of remaining Rubicon storage on Middle Fork No. 3 project considered: The power capacity available 90 per cent of the time was estimated under these conditions to be (See Table No. 7.)	80,000

23. Estimates have been made of the cost of developments under assumptions 1, 3, and 4. These estimates are $12,189,000, $21,250,000, and $20,121,000, respectively. Condition No. 4 would probably obtain if upper Rubicon water were diverted to Silver Creek, and condition No. 3, if this diversion were not made. The cost per horsepower available 90 per cent of the time is estimated as $252 and $244 under assumptions 4 and 3, respectively.

TABLE No. 2.—*Power capacity Middle Fork projects with no diversion from Rubicon or North Fork*

Year and month	Flow from French Meadows (drainage area 47.1 square miles)	Stored (+) released (−) French Meadows reservoir	In French Meadows reservoir (capacity, 64,000 acre-feet)	Controlled flow to No. 1 power house (capacity conduit, 200 second-feet)	Power developed No. 1 power house (head, 2,000 feet)	Diverted from Middle Fork, American River at No. 2 intake	Total flow to power house No. 2 (capacity, 300 second-feet)	Power developed No. 2 power house; head 1,675 feet	Flow at gauging station on Middle Fork	Correction for French Meadows storage	Controlled flow at No. 3 power house	Utilized flow at No. 3 power house	Power developed at No. 3 power house (head, 345 feet)	Total power developed
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1911	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. P.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*H. P.*
July	189	----------	1,067	189	[2] 18,200	60	249	[2] 23,500	1,046	0	1,046	350	[2] 9,600	51,300
August	33	−81	986	114	18,200	[a]	123	16,000	150	−81	231	231	6,400	40,600
September	11	−103	883	114	18,200	7	121	15,800	99	−103	202	202	5,600	39,600
1911–12														
October	10	−104	[1] 734	114	18,200	7	121	15,800	116	−104	220	220	6,100	40,100
November	14	−100	634	114	18,200	8	122	16,000	141	−100	241	241	6,700	40,900
December	9	−105	529	114	18,200	8	122	16,000	148	−105	253	253	7,000	41,200
January	16	−98	431	114	18,200	19	133	17,400	326	−98	424	350	9,600	45,200
February	28	−86	345	114	18,200	19	133	17,400	340	−86	426	350	9,600	45,200
March	61	−53	292	114	18,200	43	157	20,500	757	−53	810	350	9,600	48,300
April	122	+8	300	114	18,200	62	176	23,000	1,090	+8	1,082	350	9,600	50,800
May	405	+291	591	114	18,200	219	333	23,500	3,820	+291	3,529	350	9,600	51,300
June	243	+129	720	114	18,200	112	226	23,500	1,960	+129	1,831	350	9,600	51,300
July	62	−52	668	114	18,200	17	131	17,100	298	−52	350	350	9,600	44,900
August	18	−96	572	114	18,200	5	119	15,600	97	−96	193	193	5,300	39,100
September	23	−91	481	114	18,200	8	122	16,000	146	−91	237	237	6,500	40,700
1912–13														
October	8	−106	[1] 330	114	18,200	5	119	15,600	96	−106	202	202	5,600	39,400
November	73	−41	289	114	18,200	32	146	19,100	557	−41	598	350	9,600	46,900
December	25	−89	200	114	18,200	18	132	17,300	308	−89	397	350	9,600	45,100
January	23	−91	109	114	18,200	53	167	21,800	921	−91	1,012	350	9,600	49,600
February	50	−64	45	114	18,200	30	144	18,800	517	−64	581	350	9,600	46,600
March	77	−37	8	114	18,200	31	145	19,000	550	−37	587	350	9,600	46,800
April	264	+150	158	114	18,200	202	316	23,500	3,530	+150	3,380	350	9,600	51,300
May	455	+341	499	114	18,200	284	398	23,500	4,970	+341	4,629	350	9,600	51,300
June	179	+65	564	114	18,200	15	129	16,900	1,490	+65	1,425	350	9,600	44,700
July	55	−59	505	114	18,200	85	199	23,500	367	−59	426	350	9,600	51,300
August	20	−94	411	114	18,200	11	125	16,400	187	−94	281	281	7,800	42,400
September	9	−105	306	114	18,200	4	118	15,400	75	−105	180	180	5,000	38,600
1913–14														
October	5	−109	[1] 152	114	18,200	4	118	15,400	69	−109	178	178	4,900	38,500
November	13	−101	51	114	18,200	10	124	16,200	180	−101	281	281	7,800	42,200
December	70	−44	7	114	18,200	55	169	22,100	966	−44	1,010	350	9,600	49,900
January	281	+167	174	114	18,200	439	553	23,500	7,680	+167	7,513	350	9,600	51,300
Total	2,851	----------	----------	3,009	564,200	1,881	5,490	585,100	32,997	----------	33,755	9,349	257,100	1,406,400
Mean	92	----------	----------	116	18,200	60	177	18,900	1,064	----------	1,088	302	8,300	45,400

[1] Evaporation is taken care of by deducting the total estimated evaporation from the reservoir on Oct. 1 of each year. Evaporation is estimated at the reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.

The estimated evaporation is as follows: French Meadows Reservoir, 45 second-feet-months.

[2] Installations at Nos. 1, 2, and 3 are taken as 36,000, 45,000 and 15,000 horsepower, respectively. Maximum average outputs for one month are taken as 18,200, 23,500, and 9,600 horsepower, respectively

TABLE No. 3.—*Estimate of flow of upper Rubicon River*

Year and month	Flow from Rubicon above Rock Bound Lake (drainage area, 34 square miles)	Flow from Rubicon below Rock Bound Lake, and above American River Water & Power Co. diversion (drainage area, 59.5 square miles)	Year and month	Flow from Rubicon above Rock Bound Lake (drainage area, 34 square miles)	Flow from Rubicon below Rock Bound Lake, and above American River Water & Power Co. diversion (drainage area, 59.5 square miles)
1	2	3	1	2	3
	Second-feet	*Second-feet*		*Second-feet*	*Second-feet*
1911			1912–13		
July	290	238	December	12	32
August	42	42	January	15	30
September	6	12	February	34	63
			March	52	98
1911–12			April	193	334
October	5	13	May	461	574
November	11	17	June	243	226
December	6	11	July	83	69
January	11	20	August	23	26
February	13	36	September	4	11
March	22	79			
April	76	154	1913–14		
May	367	511	October	1	6
June	387	307	November	9	17
July	90	78	December	34	89
August	13	23	January	126	355
September	17	29			
			Total	2,715	3,603
1912–13			Mean	87	116
October	4	11			
November	56	92			

NOTE.—Column 2 is estimated by watershed ratio from flow of Rubicon River at Rubicon Springs (drainage area, 31.6 square miles). Column 3 is estimated by watershed ratio from flow of Rubicon River at Quintette (drainage area, 198 square miles).

TABLE No. 4.—*Power capacity Middle Fork projects with diversion of 93.5 square miles of upper Rubicon drainage to French Meadows and no diversion from Rubicon to Silver Creek*

(Period considered: July, 1911, to January, 1914, inclusive)

No. 1 project:		
Mean utilized flow at No. 1 project with no diversions to Middle Fork (see Table 2, column 5)	second-feet	116
Estimated mean diversion regulated at French Meadows from Rubicon above Rock Bound, 34 square miles (see Table 10, column 2)	second-feet	87
Estimated mean diversion from Rubicon above American River Water & Power Co.'s proposed diversion and below Rock Bound, 59.5 square miles, regulated at French Meadows. Flow estimated by watershed ratio from flow Rubicon at Quintette	second-feet	116
Mean utilized flow at No. 1 project with water from Rubicon	second-feet	319
Power capacity No. 1 project—319 x 2,000 x 0.08	horsepower	51,000
No. 2 project:		
Estimated mean utilized flow up to 373 second-feet at No. 2 project with no diversion to Middle Fork (see Table 2, column 8)	second feet	170
Rubicon diversions 87+116 (see above)	do	203
Mean utilized flow at No. 2 project with water from Rubicon	second-feet	373
Power capacity No. 2 project—373 x 1,675 x 0.08	horsepower	50,000
No. 3 project:		
Mean utilized flow up to 350 second-feet at No. 3 project with no diversions to Middle Fork (see Table 2, column 13)	second-feet	302
It is estimated from Table 3, columns 2 and 3, that the total diversion from the 93.5 square miles of Rubicon during 13 months, August to December, 1911, July to October, 1912, and August to November, 1913, inclusive, when no water is wasted at No. 3 project, is 527 second-feet-months, equivalent to a mean of 40 second-feet. Since this water would have been used at No. 3 project whether or not diverted to French Meadows, the net gain by the diversion to French Meadows, not taking into consideration the storage developed by Rubicon projects, is the 203 second-feet gained by Rubicon diversion at projects Nos. 1 and 2 (see above) less 40 second-feet	second-feet	163
Mean utilized flow at No. 3 project	do	465
Power capacity No. 3 project—465 x 345 x 0.08	horsepower	13,000
Summary:		
No. 1 project	do	51,000
No. 2 project	do	50,000
No. 3 project	do	13,000
Total	do	114,000

TABLE No. 5.—*Power capacity Middle Fork projects with diversion of 43 square miles drainage area from North Fork*

(Period considered: July, 1911, to January, 1914)

No. 1 project:		
Mean utilized flow at No. 1 project with no diversion to Middle Fork (see Table 2, column 5)	second-feet	116
Estimated mean diversion from North Fork with tunnel capacity of 300 second-feet and with flow equalized in French Meadows Reservoir	second-feet	90
Mean utilized flow at No. 1 project with North Fork	do	206
Power capacity No. 1 project—206 x 2,000 x 0.08	horsepower	33,000
No. 2 project:		
Mean utilized flow up to 247 second-feet at No. 2 project with no diversion to Middle Fork (estimated from Table 2, column 8)	second-feet	157
Regulated diversion from North Fork	do	90
Mean utilized flow No. 2 project with North Fork	do	247
Power capacity No. 2 project—247 x 1,675 x 0.08	horsepower	33,000
No. 3 project:		
Mean utilized flow No. 3 project up to 400 second-feet with no diversion to Middle Fork (estimated from Table 2, column 12)	second-feet	330
Regulated diversion from North Fork	do	90
Mean utilized flow No. 3 project with North Fork	do	420
Power capacity No. 3 project—420 x 345 x 0.08	horsepower	12,000
Summary:		
No. 1 project	do	33,000
No. 2 project	do	33,000
No. 3 project	do	12,000
Total	do	78,000

TABLE No. 6.—*Power capacity Middle Fork projects with diversion of upper North Fork to French Meadows, and with effect of Rubicon project storage*

Project No. 1:		
Average capacity July, 1911, to January, 1914 (see Table 5)	horsepower	33,000
Project No. 2:		
Average capacity July, 1911, to January, 1914 (see Table 5)	do	33,000
Project No. 3:		
Mean utilized flow up to 600 second-feet capacity at middle Fork No. 3 project (estimated from Table 2, column 12)	second-feet	422
Effect of North Fork diversion (see Table 5)	do	90
Effect of regulation of Rubicon projects less irrigation of Georgetown Ridge, estimated as follows: The recorded flow of the Rubicon River at Quintette, Calif., with 198 miles of drainage area is a fair indication of natural run-off from area tributary to Rubicon projects, the total drainage to which, including Pilot Creek, is 213.9 square miles, being almost identical with Rubicon drainage at Quintette. The total flow at Quintette for the 13 months (August to December, 1911, July to October, 1912, and August to November, 1913, inclusive) in the period from July, 1911, to January, 1914, when water was not wasted at Middle Fork project No. 3, as shown by Table 2, column 13, is 1,397 second-feet-months, or a mean of 107 second-feet. The mean regulated flow through Rubicon No. 4 project for the 13 months, as shown by Table 8, column 33, is 4,359 second-feet-months, or a mean of 335 second-feet. The gain therefore due to regulation of Rubicon storage less irrigation water for Georgetown Ridge is 335−107	second-feet	228
Mean utilized flow Middle Fork project No. 3 with Rubicon projects regulation and North Fork diverted to French Meadows	second-feet	740
Power capacity No. 3 project with Rubicon projects regulation and North Fork diverted to French Meadows—740 x 345 x 0.08	horsepower	20,000
Power capacity No. 3 project with North Fork diverted to French Meadows without Rubicon projects regulation (see Table 5)	horsepower	12,000
Gain at Middle Fork No. 3 project due to regulation of Rubicon projects	horsepower	8,000
Summary:		
No. 1 project	do	33,000
No. 2 project	do	33,000
No. 3 project	do	20,000
Total	do	86,000

TABLE No. 7.—*Power capacity Middle Fork projects with diversion of upper North Fork water to French Meadows and upper Rubicon water to Silver Creek*

Project No. 1:		
Average capacity July, 1911, to January, 1914 (see Table 5)	horsepower	33,000
Project No. 2:		
Average capacity July, 1911, to January, 1914 (see Table 5),	horsepower	33,000
Project No. 3:		
Mean utilized flow No. 3 project up to 400 second-feet with no diversion to Middle Fork (estimated from Table 2, col. 12)	second-feet	330
Regulated diversion from North Fork	do	90
Effect of full regulation of all Rubicon projects with no diversion to Silver Creek (see Table 6)	second-feet	228
Total	do	648
Mean flow diverted to Silver Creek (see Table 10, col. 13)	do	146
Remainder	do	502
Power capacity No. 3 project with North Fork diverted to French Meadows, upper Rubicon diverted to Silver Creek and with benefit of remainder of Rubicon storage considered—502 x 345 x 0.08	horsepower	14,000
Power capacity No. 3 project with North Fork diverted to French Meadows and without consideration of regulation of Rubicon projects	horsepower	12,000
Gain	do	2,000
Summary:		
No. 1 project	do	33,000
No. 2 project	do	33,000
No. 3 project	do	14,000
Total	do	80,000

TABLE No. 6.—*Power capacity Middle Fork projects with diversion of upper North Fork to French Meadows, and with effect of Rubicon project storage*

Project No. 1:		
Average capacity July, 1911, to January, 1914 (see Table 5)	horsepower	33,000
Project No. 2:		
Average capacity July, 1911, to January, 1914 (see Table 5)	do	33,000
Project No. 3:		
Mean utilized flow up to 600 second-feet capacity at middle Fork No. 3 project (estimated from Table 2, column 12)	second-feet	422
Effect of North Fork diversion (see Table 5)	do	90
Effect of regulation of Rubicon projects less irriation of Georgetown Ridge, estimated as follows: The recorded flow of the Rubicon River at Quintette, Calif., with 198 miles of drainage area is a fair indication of natural run-off from area tributary to Rubicon projects, the total drainage to which, including Pilot Creek, is 213.9 square miles, being almost identical with Rubicon drainage at Quintette. The total flow at Quintette for the 13 months (August to December, 1911, July to October, 1912, and August to November, 1913, inclusive) in the period from July, 1911, to January, 1914, when water was not wasted at Middle Fork project No. 3, as shown by Table 2, column 13, is 1,397 second-feet-months, or a mean of 107 second-feet. The mean regulated flow through Rubicon No. 4 project for the 13 months, as shown by Table 8, column 33, is 4,359 second-feet-months, or a mean of 335 second-feet. The gain therefore due to regulation of Rubicon storage less irrigation water for Georgetown Ridge is 335−107	second-feet	228
Mean utilized flow Middle Fork project No. 3 with Rubicon projects regulation and North Fork diverted to French Meadows	second-feet	740
Power capacity No. 3 project with Rubicon projects regulation and North Fork diverted to French Meadows—740 x 345 x 0.08	horsepower	20,000
Power capacity No. 3 project with North Fork diverted to French Meadows without Rubicon projects regulation (see Table 5)	horsepower	12,000
Gain at Middle Fork No. 3 project due to regulation of Rubicon projects	horsepower	8,000
Summary:		
No. 1 project	do	33,000
No. 2 project	do	33,000
No. 3 project	do	20,000
Total	do	86,000

TABLE No. 7.—*Power capacity Middle Fork projects with diversion of upper North Fork water to French Meadows and upper Rubicon water to Silver Creek*

Project No. 1:		
Average capacity July, 1911, to January, 1914 (see Table 5)	horsepower	33,000
Project No. 2:		
Average capacity July, 1911, to January, 1914 (see Table 5),	horsepower	33,000
Project No. 3:		
Mean utilized flow No. 3 project up to 400 second-feet with no diversion to Middle Fork (estimated from Table 2, col. 12)	second-feet	330
Regulated diversion from North Fork	do	90
Effect of full regulation of all Rubicon projects with no diversion to Silver Creek (see Table 6)	second-feet	228
Total	do	648
Mean flow diverted to Silver Creek (see Table 10, col. 13)	do	146
Remainder	do	502
Power capacity No. 3 project with North Fork diverted to French Meadows, upper Rubicon diverted to Silver Creek and with benefit of remainder of Rubicon storage considered—502 x 345 x 0.08	horsepower	14,000
Power capacity No. 3 project with North Fork diverted to French Meadows and without consideration of regulation of Rubicon projects	horsepower	12,000
Gain	do	2,000
Summary:		
No. 1 project	do	33,000
No. 2 project	do	33,000
No. 3 project	do	14,000
Total	do	80,000

RUBICON DEVELOPMENTS

24. The term "Rubicon developments" is used in this report to designate a series of projects developing storage on the Rubicon watershed and a series of power drops from Loon Lake Reservoir (crest elevation 6,418) to the mouth of the Rubicon.

25. Storage possibilities on the upper Rubicon River can best be developed, it is believed, by constructing a storage and diversion dam on the upper Rubicon River above Rubicon Springs, connecting this reservoir by tunnels and conduits with Rock Bound, Buck Island, and Loon Lakes, and constructing dams at the outlets of these lakes. Loon Lake has already been developed to a capacity of 8,000 acre-feet by the Truckee River Water & Power Co. The combined storage that can be economically developed by Rubicon diversion, Rock Bound, and Buck Island Lakes is estimated to be 24,000 acre-feet. The most economical storage in Loon Lake is estimated at 47,000 acre-feet. It has also been planned to divert 4 square miles of the upper drainage of Little South Fork of the Rubicon into Loon Lake, thus making a total area tributary to these upper reservoirs of 47 square miles.

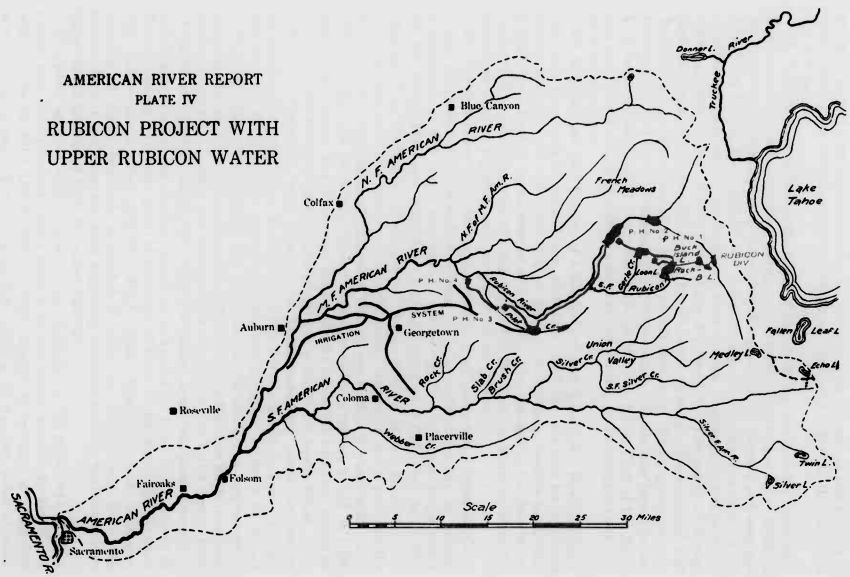
26. It is believed that the fall of 5,268 feet between Loon Lake, elevation 6,418 feet, and the mouth of the Rubicon, elevation 1,150 feet, can best be developed in four projects. Of this total drop, it will be economically feasible to develop a total head, forebay to tailrace, of 4,755 feet. The remaining 513 feet is lost in reservoir drawdown, grade of conduits, and in the Rubicon River between the tailrace of the No. 4 project and the mouth of the Rubicon.

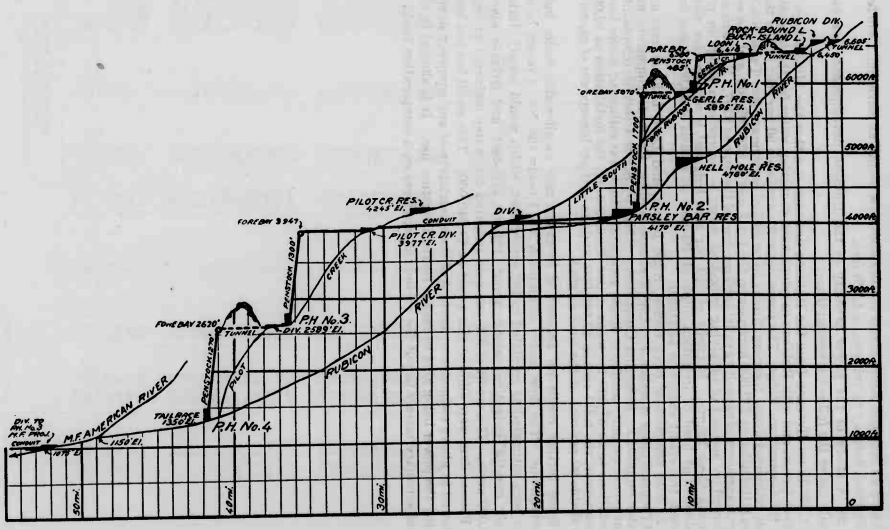
27. The first power drop would be between Loon Lake and a point on Gerle Creek, approximately 2 miles downstream. The head from forebay to tailrace is estimated at 485 feet. Immediately below this No. 1 power house would be the Gerle Meadows Reservoir, with capacity of 8,520 acre feet. The drainage from an additional area of 13 square miles is picked up here. The No. 2 project would be between Gerle Meadows Reservoir and a point on the Rubicon River approximately 2½ miles almost due west of the reservoir. It is estimated that the head from forebay to tailrace of this project would be 1,700 feet. The Parsley Bar Reservoir, with capacity of 14,000 acre-feet, would be located on the Rubicon River immediately below the No. 2 power house. The Hell Hole Reservoir, with capacity of 32,000 acre-feet, would be located on the Rubicon River about 4 miles above the Parsley Bar Reservoir. Parsley Bar and Hell Hole together would have directly tributary to them 95 square miles of Rubicon drainage below the Rock Bound diversion. A long concrete-lined conduit would divert water on the left bank of the Rubicon River, conducting the water from Parsley Bar Reservoir to a point on the Little South Fork of the Rubicon, where 30.9 square miles of drainage from this stream would be picked up. Thence the conduit would go to a point on Pilot Creek known as Bacchis, where 19 square miles of drainage of Pilot Creek would be diverted into the conduit. The proposed Pilot Creek Reservoir, with estimated capacity of 5,555 acre-feet, is located 2 miles up Pilot Creek from this point. Also at this point the ditch supplying irrigation water to the Georgetown Ridge would branch off from the power conduit.

At a point approximately 3 miles below Bacchis, on the right side of Pilot Creek, the No. 3 penstock would drop from the power conduit to the No. 3 power house on Pilot Creek, where a head, forebay to tailrace, of 1,300 feet would be developed. The No. 4 project, picking up 9 square miles of additional Pilot Creek drainage, would divert from Pilot Creek immediately below the No. 3 power house to a conduit 3 miles long. The No. 4 power house is

AMERICAN RIVER REPORT
PLATE IV

RUBICON PROJECT WITH UPPER RUBICON WATER





located on Rubicon River about 2 miles above its mouth at elevation 1,340 feet. The head, forebay to tailrace, is 1,270 feet.

28. A study of the power capacity of the Rubicon developments has been made under the following assumptions:

1. With no diversion from the Rubicon drainage to either the Middle Fork or Silver Creek, and with Rubicon developments supplying water for the irrigation of the Georgetown Ridge: The power capacity available 90 per cent of the time was estimated under these conditions to be 99,000 horsepower (see Table No. 8,) the installation as 212,000 horsepower, the total cost as $20,509,000, and the cots per horsepower of capacity available 90 per cent of the time as $207. No credit was allowed on account of supplying irrigation water to Georgetown Ridge in preparing these figures. If credit of $20 per acre irrigated is allowed for water delivered at head of irrigation ditch at Bacchis on a basis of 25,000 acres irrigated, this credit should be $500,000.

2. With diversion of Rock Bound, Buck Island, and Loon Lake storage and 80.7 square miles of upper Rubicon drainage to Silver Creek developments, and water supplied for irrigating Georgetown Ridge by Silver Creek developments: The power capacity available 90 per cent of the time was estimated under these conditions to be 37,000 horsepower (see Table No. 9), the installation as 80,000 horsepower, the total cost as $7,960,000, and the cost per horsepower of capacity available 90 per cent of the time as $215.

Some further credit on account of irrigation may be allowable under both assumptions. The flow under assumption No. 1 below the No. 4 power house has been estimated as regulated to 365 second-feet, which would supply during a six months' irrigation season about 131,000 acre-feet and irrigate about 52,000 acres. If a credit of $20 per acre irrigated for water delivered at crest of Folsom dam were allowed this would be $1,040,000. This credit has not been allowed in above estimates on account of the uncertainty of any company developing the power being able to realize on the irrigation use. It is allowed in the final summary merely to put the various alternatives on a comparative basis.

REDUCTION RATIO 15:1

2.5 mm

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890

2.0 mm

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abcdefghijklmnopqrstuvwxyz1234567890

1.5 mm

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abcdefghijklmnopqrstuvwxyz1234567890

PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC

200 mm

150 mm

100 mm

A3

A4

A5

1.0

1.1

1.25

1.4

1.6

1.8

1.0 mm

1.5 mm

2.0 mm

2.5 mm

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890

PRECISION℠ RESOLUTION TARGETS

A&P International
2715 Upper Afton Road, St. Paul, MN 55119-4760
612/738-9329 FAX 612/738-1496

4.5 mm

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890

3.5 mm

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz1234567890

3.0 mm

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz1234567890

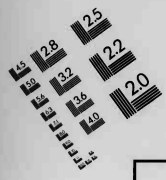
TABLE NO. 8.—*Power capacity, Rubicon projects, with no diversion to Silver Creek*

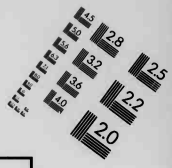
Year and month	1	Total flow in Rock Bound Lake and Buck Island (drainage area, 34 square miles)	Stored (+) released (−) Rock Bound Lake and Buck Island	In Rock Bound Lake and Buck Island (24,000 acre-feet capacity)	Flow in Rock Bound-Loon Lake conduit (capacity, 500 second-feet)	Flow to Loon Lake, 9 square miles and 4 square miles diverted from Little South Fork, Rubicon (total drainage, 13 square miles) (capacity conduit, 170 second-feet)	Total flow into Loon Lake	Stored (+) or released (−) Loon Lake Reservoir	In Loon Lake Reservoir (capacity, 40,000 acre-feet)	Controlled flow to power house No. 1 (capacity, 300 second-feet)	Power developed, power house No.1 (head, 485 feet)	Diverted from Gerle Creek at Gerle Meadows (drainage area, 13 square miles)	Total flow to Gerle Meadows Reservoir	Stored (+) or released (−) Gerle Meadows Reservoir	In Gerle Meadows Reservoir (capacity, 8,530 acre-feet)	Controlled flow to power house No. 2 (capacity, 300 second-feet)	Power developed, power house No. 2 (head, 1,700 feet)	Flow from Rubicon into Parsley Bar and Hell Hole Reservoirs (drainage area, 86 square miles)	Total flow to Parsley Bar and Hell Hole Reservoirs	Stored (+) or released (−) from Parsley Bar and Hell Hole Reservoirs (capacity, 13,500 and 32,000 acre-feet)	In Parsley Bar and Hell Hole Reservoirs	Controlled flow Parsley Bar conduit to Little South Fork, Rubicon (capacity, 500 second-feet)	Diverted from Little South Fork, Rubicon (drainage area 30.9 square miles)	Total flow into conduit at Little South Fork, Rubicon, to Pilot Creek	Pilot Creek at Barchi (drainage area, 19 square miles)	Stored (+) or released (−) Pilot Creek reservoir	In Pilot Creek reservoir (capacity, 5,850 acre-feet)	Total flow to Bacchis	Released to Georgetown divide irrigation ditch	Controlled flow to power house No. 3 (capacity conduit, 500 second-feet)	Power developed, power house No. 3 (head 1,100 feet)	Diverted from Pilot Creek at No. 4 intake (drainage area, 9 square miles)	Controlled flow to power house No. 4 (capacity, 500 second-feet)	Power developed, power house No. 4 (head, 1,270 feet)	Total power developed
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1911	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*H. P*
July	299		400	299	110	409			783	280	[1]7,800	32	461		143	300	[3]34,000	372	672		750	500	123	623	12		93	635	208	427	[3]39,000	3	438	[3]38,000	118,900
August	42	−48	352	90	16	106	−104	679	219	7,800	9	219	−53		90	272	34,000	66	338	−183	567	500	22	522	1	−93	0	616	208	408	39,000	0	408	38,000	118,900
September	6	−84	268	90	3	93	−87	592	180	7,000	3	183	−19		71	262	27,500	22	224	−225	342	449	7	456	7	0	0	463	125	338	35,200	2	340	34,500	104,200
1911-12																																		
October	5	−85	[1]165	90	1	91	−59	[1]498	150	5,800	3	153	−19	[1]27	172	22,400	20	192	−128	[1]188	320	7	327	13	0	0	340	33	307	31,900	3	310	31,500	92,600
November	11	−79	86	90	4	94	−46	452	140	5,400	4	144	−18	19	162	22,000	27	189	−85	103	274	9	283	17	0	0	300	4	296	30,800	4	300	30,500	85,700
December	6	−84	2	90	3	93	−47	405	140	5,400	3	143	−19	0	162	22,000	18	180	−105	0	285	6	289	12	0	0	301	4	297	30,900	3	300	30,500	86,800
January	11	−2	0	13	4	17	−188	217	205	7,900	4	209	0	0	209	28,400	32	241	0	0	241	11	252	20	0	0	272	4	268	27,900	5	273	27,700	91,800
February	13	0	0	13	4	17	−143	74	160	6,200	8	168	0	0	168	22,800	56	224	0	0	224	19	243	16	0	0	259	4	255	26,500	4	259	26,300	81,800
March	22	0	0	22	9	31	−74	0	105	4,100	17	122	0	0	122	16,600	120	242	0	0	242	40	282	20	0	0	302	8	294	30,600	5	299	30,400	91,700
April	76	0	0	76	27	103	−71	71	32	1,200	34	66	+23	0	23	3,100	240	263	0	0	263	80	343	41	0	0	404	8	396	41,000	6	406	39,000	94,000
May	367	+167	167	200	136	336	+316	387	20	800	112	132	+161	124	31	4,200	797	828	+620	620	208	265	473	77	+66	66	484	83	401	39,000	19	420	38,000	82,000
June	387	+233	400	154	143	297	+267	664	0	0	67	67	+19	143	48	6,500	479	527	+130	750	367	159	526	27	+27	93	556	142	414	39,000	7	421	38,000	83,500
July	90	0	400	90	33	123	−42	642	165	6,400	17	182	−5	138	187	25,400	123	310	−141	609	451	41	492	11	−30	63	533	208	325	30,900	3	328	33,300	96,000
August	13	−290	200	213	4	217	−42	684	175	6,800	5	180	−17	121	197	26,800	36	233	−229	380	462	12	474	6	−63	0	543	208	335	34,000	3	338	34,100	102,500
September	17	0	200	17	6	23	−152	532	175	6,800	6	181	−16	105	197	26,800	45	242	−194	186	496	15	451	9	0	0	460	125	335	34,800	2	337	34,200	102,600
1912-13																																		
October	4	−200	0	186	1	187	+12	[1]509	175	6,800	2	177	−21	[1]69	198	26,900	16	214	−144	[1]16	358	5	363	6	0	0	369	33	336	34,900	1	337	34,200	102,800
November	56	0	0	56	20	76	−101	408	177	6,900	20	197	−3	66	200	27,200	143	343	+70	86	273	46	321	21	0	0	342	4	338	35,200	5	343	34,800	104,100
December	12	0	0	12	4	16	−139	269	175	6,800	7	182	−16	50	198	26,900	49	247	−83	23	310	16	326	14	0	0	340	4	336	34,900	3	339	34,400	105,000
January	15	0	0	15	6	21	−164	85	185	7,200	6	191	−17	33	208	28,300	46	254	−23	0	277	15	292	20	0	0	312	4	308	32,000	5	313	34,800	102,300
February	34	0	0	34	13	47	−83	0	132	5,100	14	146	−9	24	155	21,000	97	252	0	0	252	36	288	18	0	0	302	4	298	31,000	4	302	30,700	84,200
March	52	0	0	52	19	71	0	0	71	2,800	21	92	−12	12	104	14,100	152	256	0	0	256	50	306	26	0	0	332	8	324	33,700	7	331	33,600	84,200
April	160	0	0	160	78	271	+271	271	0	0	73	73	+73	65	0	0	520	520	+153	153	367	173	540	91	+46	46	588	0	588	39,000	24	500	39,000	77,900
May	461	+307	357	104	170	274	+274	545	0	0	125	125	+38	143	67	9,100	893	962	+597	750	365	298	663	47	+47	93	663	83	500	39,000	12	500	38,000	86,100
June	243	+63	400	200	90	290	+205	750	85	3,300	49	134	−8	135	142	19,200	553	695	0	750	695	117	812	21	+93	93	653	142	491	38,000	5	496	38,000	76,500
July	83	0	400	83	30	113	−131	619	244	7,400	15	259	−18	117	277	34,000	108	385	−160	590	500	36	536	8	−33	60	571	208	369	38,400	2	371	37,700	117,900
August	23	0	400	23	9	32	−178	441	210	7,800	6	216	−27	90	243	33,600	40	283	−226	364	500	13	513	6	−69	0	579	208	371	38,400	1	372	37,800	117,200
September	4	0	400	4	1	5	−205	236	210	7,800	2	212	−31	59	243	33,000	17	260	−134	290	394	6	400	5	0	0	405	125	280	29,100	1	281	28,700	98,600
1913-14																																		
October	1	−200	[1]182	201	0	201	−10	[1]191	211	7,800	1	212	−32	[1]12	244	33,200	9	253	−152	[1]52	405	3	408	6	0	0	414	33	381	39,000	1	382	38,600	118,000
November	9	−182	0	191	3	194	−16	175	210	7,800	4	214	−12	0	226	32,700	26	252	−52	0	304	9	313	15	0	0	328	4	324	33,700	4	328	33,300	107,500
December	36	0	0	36	13	49	−161	14	210	7,800	19	229	0	0	229	31,100	139	368	0	0	368	46	414	42	0	0	456	4	452	36,000	10	462	36,000	115,900
January	126	0	0	126	46	172	−14	0	186	7,200	78	264	0	0	264	34,000	553	817	+494	494	323	184	507	286	+93	93	700	4	560	39,000	71	560	38,000	118,200
Total	2,717		3,063	1,696	4,099				4,618	172,200	786	5,333			5,470	730,000	5,616	11,086			11,017	1,867	12,884	924			13,808	2,248	11,204	1,084,400	227	11,324	1,071,000	3,038,000
Mean	88		99	32	109	131			149	5,554	25	178			176	23,548	181	357			355	60	415	29			445	72	361	35,000	7	365	34,500	98,600

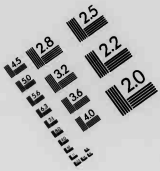
[1] Evaporation is taken care of by deducting the total estimated evaporation from each reservoir on Oct. 1 of each year. Evaporation is estimated at each reservoir as 2 feet in depth on 60 per cent of the maximum area of the reservoir.
The estimated evaporations are as follows: (1) Rock Bound Lake, 18 second-feet months; (2) Loon Lake, 35 second-feet months; (3) Gerle Meadows, 15 second-feet months; (4) Hell Hole and Parsley Bar, 26 second-feet months.
[2] The installed capacities at No. 1, No. 2, No. 3, and No. 4 projects are 12,600, 48,000, 76,000, and 76,600 horsepower, respectively. The maximum average output for any month has been taken as 7,800, 34,000, 39,000, and 38,000, respectively.

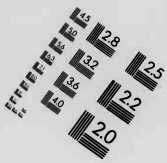
REDUCTION RATIO 10:1

PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC









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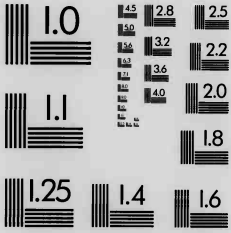

ABCDEFGHIJKLMNOPQRSTUVWXYZ
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1.0 mm

1.5 mm

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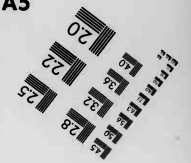
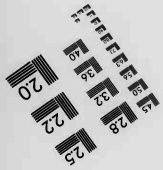
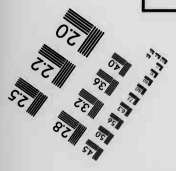
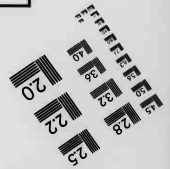








PRECISION℠ RESOLUTION TARGETS

A&P International
2715 Upper Afton Road, St. Paul, MN 55119-4760
612/738-9329 FAX 612/738-1496

TABLE No. 8.—*Power capacity, Rubicon projects, with no diversion to Silver Creek*

Year and month	Total flow to Rock Bound Lake and Buck Island (drainage area, 34 square miles)	Stored (+) released (−) Rock Bound Lake and Buck Island	In Rock Bound Lake and Buck Island (24,000 acre-feet capacity)	Flow in Rock Bound-Locn Lake conduit (capacity, 500 second-feet)	Flow to Loon Lake, 9 square miles and 4 square miles diverted from Little South Fork, Rubicon (total drainage, 13 square miles) (capacity conduit, 170 second-feet)	Total flow into Loon Lake	Stored (+) or released (−) Loon Lake Reservoir	In Loon Lake Reservoir (capacity, 47,000 acre-feet)	Controlled flow to power house No. 1 (capacity, 300 second-feet)	Power developed, power house No.1 (head, 485 feet)	Diverted from Gerle Creek at Gerle Meadows (drainage area, 13 square miles)	Total flow to Gerle Meadows Reservoir	Stored (+) or released (−) Gerle Meadows Reservoir	In Gerle Meadows Reservoir (capacity, 8,520 acre-feet)	Controlled flow to power house No. 2 (capacity, 350 second-feet)	Power developed, power house No. 2 (head, 1,700 feet)	Flow from Rubicon into Parsley Bar and Hell Hole Reservoirs (drainage area, 95 square miles)	Total flow to Parsley Bar and Hell Hole Reservoirs	Stored (+) or released (−) from Parsley Bar and Hell Hole Reservoirs (capacity, 13,000 and 32,000 acre-feet)	In Parsley Bar and Hell Hole Reservoirs	Controlled flow Parsley Bar conduit to Little South Fork, Rubicon (capacity, 500 second-feet)	D fr So R ((a
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1911	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	
July	299		400	299	110	409		783	280	[2]7,800	52	461		143	300	[2]34,000	372	672		750	506	
August	42	−48	352	90	16	106	−104	679	210	7,800	9	219	−53	90	272	34,000	66	338	−183	567	500	
September	6	−84	268	90	3	93	−87	592	180	7,000	3	183	−19	71	202	27,500	22	224	−225	342	449	
1911-12																						
October	5	−85	[1]165	90	1	91	−59	[1]498	150	5,800	3	153	−19	[1]37	172	23,400	29	192	−128	[1]188	320	
November	11	−79	86	90	4	94	−46	452	140	5,400	4	144	−18	19	162	22,000	27	189	−85	103	274	
December	6	−84	2	90	3	93	−47	405	140	5,400	3	143	−19	0	162	22,000	18	180	−103	0	283	
January	11	−2	0	13	4	17	−188	217	205	7,800	4	209	0	0	209	28,400	32	241	0	0	241	
February	13	0	0	13	4	17	−143	74	160	6,200	8	168	0	0	168	22,800	56	224	0	0	224	
March	22	0	0	22	9	31	−71	0	105	4,100	17	122	0	0	122	16,600	120	242	0	0	242	
April	76	0	0	76	27	103	+71	71	32	1,200	34	66	+23	23	43	5,800	240	283	0	0	283	
May	367	+167	167	200	136	336	+316	387	20	800	112	132	+101	124	31	4,200	797	828	+620	620	208	
June	387	+233	400	154	143	297	+297	684	0	0	67	67	+19	143	48	6,500	479	527	+130	750	397	
July	90	0	400	90	33	123	−42	642	165	6,400	17	182	−5	138	157	25,400	123	310	−141	609	451	
August	13	−200	200	213	4	217	+42	684	175	6,800	5	180	−17	121	197	26,800	36	233	−229	380	462	
September	17	0	200	17	6	23	−152	532	175	6,800	6	181	−16	105	197	26,800	45	242	−194	186	436	
1912-13																						
October	4	−200	[1]0	186	1	187	+12	[1]509	175	6,800	2	177	−21	[1]69	198	26,900	16	214	−144	[1]16	358	
November	56	0	0	56	20	76	−101	408	177	6,900	20	197	−3	66	200	27,200	143	343	+70	86	273	
December	12	0	0	12	4	16	−159	249	175	6,800	7	182	−16	50	198	26,900	49	247	−63	23	310	
January	15	0	0	15	6	21	−164	85	185	7,200	6	191	−17	33	208	28,300	46	254	−23	0	277	
February	34	0	0	34	13	47	−85	0	132	5,100	14	146	−9	24	155	21,000	97	252	0	0	252	
March	52	0	0	52	19	71	0	0	71	2,800	21	92	−12	12	104	14,100	152	256	0	0	256	
April	193	0	0	193	78	271	+271	271	0	0	73	73	+73	85	0	0	520	520	+153	153	367	
May	461	+357	357	104	170	274	+274	545	0	0	125	125	+58	143	67	9,100	895	962	+307	750	365	
June	243	+43	400	200	90	290	+205	750	85	3,300	49	134	−8	135	142	19,200	353	495	0	750	495	
July	83	0	400	83	30	113	−131	619	244	7,800	15	259	−18	117	277	34,000	108	385	−160	590	500	
August	23	0	400	23	9	32	−178	441	210	7,800	6	216	−27	90	243	33,000	40	283	−226	364	500	
September	4	0	400	4	1	5	−205	236	210	7,800	2	212	−31	59	243	33,000	17	260	−134	230	394	
1913-14																						
October	1	−200	[1]182	201	0	201	−10	[1]191	211	7,800	1	212	−32	[1]12	244	33,200	9	253	−152	[1]52	405	
November	9	−182	0	191	3	194	−16	175	210	7,800	4	214	−12	0	226	32,700	26	252	−52	0	304	
December	36	0	0	36	13	49	−161	14	210	7,800	19	229	0	0	229	31,100	139	368	0	0	368	
January	126	0	0	126	46	172	−14	0	186	7,200	78	264	0	0	264	34,000	553	817	+494	494	323	
Total	2,717			3,063	1,006	4,069			4,618	172,200	786	5,533			5,470	730,000	5,616	11,086			11,017	
Mean	88			99	32	131			149	5,554	25	178			176	23,548	181	357			355	

[1] Evaporation is taken care of by deducting the total estimated evaporation from each reservoir on Oct. 1 of each year. Evaporation is estimated at each reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.
The estimated evaporations are as follows: (1) Rock Bound Lake, 18 second-feet months; (2) Loon Lake, 25 second-feet months; (3) Gerle Meadows, 15 second-feet months; (4) Hell Hole and Parsley Bar, 26 second-feet months.
[2] The installed capacities at No. 1, No. 2, No. 3, and No. 4 projects are 12,000, 48,000, 76,000, and 76,000 horsepower, respectively. The maximum average output for any month has been taken as 7,800, 34,000, 39,000, and 38,000, respectively.

TABLE No. 8.—*Power capacity, Rubicon projects, with no diversion to Silver Creek*

Total flow to Gerle Meadows Reservoir	Stored (+) or released (−) Gerle Meadows Reservoir	In Gerle Meadows Reservoir (capacity, 8,520 acre-feet)	Controlled flow to power house No. 2 (capacity, 350 second-feet)	Power developed, power house No. 2 (head, 1,700 feet)	Flow from Rubicon into Parsley Bar and Hell Hole Reservoirs (drainage area, 95 square miles)	Total flow to Parsley Bar and Hell Hole Reservoirs	Stored (+) or released (−) from Parsley Bar and Hell Hole Reservoirs (capacity, 13,000 and 32,000 acre-feet)	In Parsley Bar and Hell Hole Reservoirs	Controlled flow Parsley Bar conduit to Little South Fork, Rubicon (capacity, 500 second-feet)	Diverted from Little South Fork, Rubicon (drainage area 30.9 square miles)	Total flow into conduit Little South Fork, Rubicon, to Pilot Creek	Pilot Creek at Bacchi (drainage area 19 square miles)	Stored (+) or released (−) Pilot Creek reservoir	In Pilot Creek reservoir (capacity, 5,555 acre-feet)	Total flow to Bacchis	Released to Georgetown divide irrigation ditch	Controlled flow to power house No. 3 (capacity conduit, 500 second-feet)	Power developed power house No. 3 (head 1,300 feet)	Diverted from Pilot Creek at No. 4 intake (drainage area, 9 square miles)	Controlled flow to power house No. 4 (capacity, 500 second-feet)	Power developed, power house No. 4 (head, 1,270 feet)	Total power developed
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Sec.-ft.	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*H. P.*
461	----------	143	300	[2]34,000	372	672	----------	750	500	123	623	12	----------	93	635	208	427	[2]39,000	3	430	[2]38,000	118,800
219	−83	90	272	34,000	66	338	−183	567	500	22	522	1	−93	0	616	208	408	39,000	0	408	38,000	118,800
183	−19	71	202	27,500	22	224	−225	342	449	7	456	7	0	0	463	125	338	35,200	2	340	34,500	104,200
153	−19	[1]37	172	23,400	20	192	−128	[1]188	320	7	327	13	0	0	340	33	307	31,900	3	310	31,500	92,600
144	−18	19	162	22,000	27	189	−85	103	274	9	283	17	0	0	300	4	296	30,800	4	300	30,500	88,700
143	−19	0	162	22,000	18	180	−103	0	283	6	289	12	0	0	301	4	297	30,900	3	300	30,500	88,800
209	0	0	209	28,400	32	241	0	0	241	11	252	20	0	0	272	4	268	27,900	5	273	27,700	91,800
168	0	0	168	22,800	56	224	0	0	224	19	243	16	0	0	259	4	255	26,500	4	259	26,300	81,800
122	0	0	122	16,600	120	242	0	0	242	40	282	20	0	0	302	5	294	30,600	5	299	30,400	91,700
66	+23	23	43	5,800	240	283	0	0	283	80	363	41	0	0	404	8	396	39,000	10	406	38,000	84,000
132	+101	124	31	4,200	797	828	+620	620	208	265	473	77	+66	66	484	83	401	39,000	19	420	38,000	82,000
67	+19	143	48	6,500	479	527	+130	750	397	159	556	27	+27	93	556	142	414	39,000	7	421	38,000	83,500
182	−5	138	187	25,400	123	310	−141	609	451	41	492	11	−30	63	533	208	325	30,900	3	328	33,300	96,000
180	−17	121	197	26,800	36	233	−229	380	462	12	474	6	−63	0	543	208	335	34,800	1	336	34,100	102,500
181	−16	105	197	26,800	45	242	−194	186	436	15	451	9	0	0	460	125	335	34,800	2	337	34,200	102,600
177	−21	[1]69	198	26,900	16	214	−144	[1]16	358	5	363	6	0	0	369	33	336	34,900	1	337	34,200	102,800
197	−3	66	200	27,200	143	343	+70	86	273	48	321	21	0	0	342	4	338	35,200	5	343	34,800	104,100
182	−16	50	198	26,900	49	247	−63	23	310	16	326	14	0	0	340	4	336	34,900	3	339	34,400	105,000
191	−17	33	208	28,300	46	254	−23	0	277	15	292	20	0	0	312	4	308	32,000	5	313	34,800	102,300
146	−9	24	155	21,000	97	252	0	0	252	32	284	18	0	0	302	4	298	31,000	4	302	30,700	87,800
92	−12	12	104	14,100	152	256	0	0	256	50	306	26	0	0	332	8	324	33,700	7	331	33,600	84,200
73	+73	85	0	0	520	520	+153	153	367	173	540	94	+46	46	588	8	500	39,000	24	500	38,000	77,000
125	+58	143	67	9,100	895	962	+597	750	365	298	663	47	+47	93	663	83	500	39,000	12	500	38,000	86,100
134	−8	135	142	19,300	353	495	0	750	495	117	612	21	0	93	633	142	491	39,000	5	496	38,000	99,600
259	−18	117	277	34,000	108	385	−160	590	500	36	536	8	−33	60	571	208	369	38,400	2	371	37,700	117,900
216	−27	90	243	33,000	40	283	−226	364	500	13	513	6	−60	0	579	208	371	38,600	1	372	37,800	117,200
212	−31	59	243	33,000	17	260	−134	230	394	6	400	5	0	0	405	125	280	29,100	1	281	28,700	98,600
212	−32	[1]12	244	33,200	9	253	−152	[1]52	405	3	408	6	0	0	414	33	381	39,000	1	382	38,000	118,000
214	−12	0	226	32,700	26	252	−52	0	304	9	313	15	0	0	328	4	324	33,700	4	328	33,300	107,500
229	0	0	229	31,100	139	368	0	0	368	46	414	42	0	0	456	4	452	39,000	10	462	38,000	115,900
264	0	0	264	34,000	553	817	+494	494	323	184	507	286	+93	93	700	4	500	39,000	71	500	38,000	118,200
5,533	----------	----------	5,470	730,000	5,616	11,086	----------	----------	11,017	1,867	12,884	924	----------	----------	13,808	2,248	11,204	1,084,800	227	11,324	1,071,000	3,058,000
178	----------	----------	176	23,548	181	357	----------	----------	355	60	415	29	----------	----------	445	72	361	35,000	7	365	34,500	98,600

[1] reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.
[2], 15 second-feet months; (4) Hell Hole and Parsley Bar, 26 second-feet months.
ge output for any month has been taken as 7,800, 34,000, 39,000, and 38,000, respectively.

TABLE NO. 9—*Power capacity, Rubicon projects with upper Rubicon diverted to Silver Creek*

Year and month	Flow to Hell Hole and Parsley Bar reservoirs (drainage area, 95 square miles)	Stored (+) or released (−) Hell Hole and Parsley Bar reservoirs	In Hell Hole and Parsley Bar reservoirs (capacity, 32,000 and 13,000 acre-feet)	Flow from Little South Fork Rubicon and Gerle Creek below Silver Creek project diversions and above Rubicon project diversion (drainage area, 10 square miles)	Flow from Pilot Creek at Bacchis (drainage area, 19 square miles)	Diverted from Pilot Creek at Bacchis to irrigate Georgetown Ridge (see column 10, Table 10)	Diverted from Pilot Creek at Bacchis to Rubicon project	Wasted	Total flow to power house No. 3	Power developed powerhouse No. 3 (head, 1,300 feet)	Diverted from Pilot Creek at No. 4 intake	Total flow to No. 4 powerhouse	Power developed No. 4 power house (head, 1,270 feet)	Total power developed
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1911	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*Sec.-ft.*	*Sec.-ft.*	*H. P.*	*H. P.*
July	372	----	750	115	12	12	0	287	200	20,800	3	203	20,000	40,800
August	66	−60	690	24	1	1	0	0	150	15,600	0	150	15,200	30,800
September	22	−120	570	8	7	7	0	0	150	15,600	2	152	15,400	31,000
1911–12														
October	20	−125	419	5	13	13	0	0	150	15,600	3	153	15,500	31,100
November	27	−104	315	4	17	4	13	0	148	15,600	4	152	15,400	31,000
December	18	−132	183	−8	12	4	8	0	150	15,600	3	153	15,500	31,100
January	32	−106	77	−4	20	4	16	0	150	15,600	5	155	15,700	31,300
February	56	−77	0	4	16	4	12	0	149	15,600	4	153	15,500	31,100
March	120	+10	10	28	20	8	12	0	150	15,600	5	155	15,700	31,300
April	240	+140	150	17	41	8	33	0	150	15,600	10	160	16,300	31,900
May	797	+600	750	34	77	77	0	31	200	20,800	19	219	20,000	40,800
June	479	0	750	68	27	27	0	347	200	20,800	7	207	20,000	40,800
July	123	−12	738	47	11	11	0	0	182	18,900	3	185	18,800	37,700
August	36	−131	607	15	6	6	0	0	182	18,900	1	183	18,600	37,500
September	45	−123	484	14	9	9	0	0	182	18,900	2	184	18,700	37,600
1912–13														
October	16	−163	295	3	6	6	0	0	182	18,900	1	183	18,600	37,500
November	143	−6	289	16	21	4	17	0	182	18,900	5	187	19,000	37,900
December	49	−120	169	3	14	4	10	0	182	18,900	3	185	18,800	37,700
January	46	−116	53	4	20	4	16	0	182	18,900	5	187	19,000	37,900
February	97	−53	0	10	18	4	14	0	174	18,000	4	178	18,100	36,100
March	132	+7	7	19	26	8	18	0	182	18,900	7	189	19,200	38,100
April	520	+463	470	39	94	8	86	0	182	18,900	24	206	20,000	38,900
May	895	+280	750	90	47	47	0	505	200	20,800	12	212	20,000	40,800
June	353	0	750	63	21	21	0	216	200	20,800	5	205	20,000	40,800
July	108	−51	699	32	8	8	0	0	191	19,900	2	193	19,600	39,500
August	40	−137	562	14	6	6	0	0	191	19,900	1	192	19,500	39,400
September	17	−169	393	5	5	5	0	0	191	19,900	1	192	19,500	39,400
1913–14														
October	9	−180	187	2	6	6	0	0	191	19,900	1	192	19,500	39,400
November	26	−151	36	3	15	4	11	0	191	19,900	4	195	19,800	39,700
December	139	−33	3	−19	42	4	38	0	191	19,900	10	201	20,000	39,900
January	553	+553	556	118	286	4	282	200	200	20,800	71	271	20,000	40,800
Total	5,616	----------	----------	[1]773	924	338	586	1,586	5,505	572,700	227	5,732	566,900	1,139,600
Mean	181	----------	----------	24	29	10	18	51	177	18,500	7	184	18,300	36,800

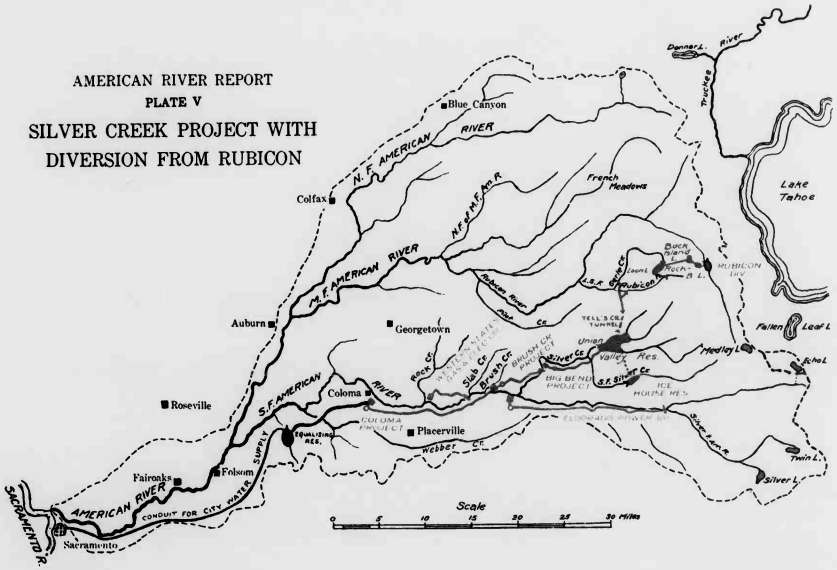
[1] Obtained by adding columns 23 and 12 of Table 8, less column 8 of Table 10.

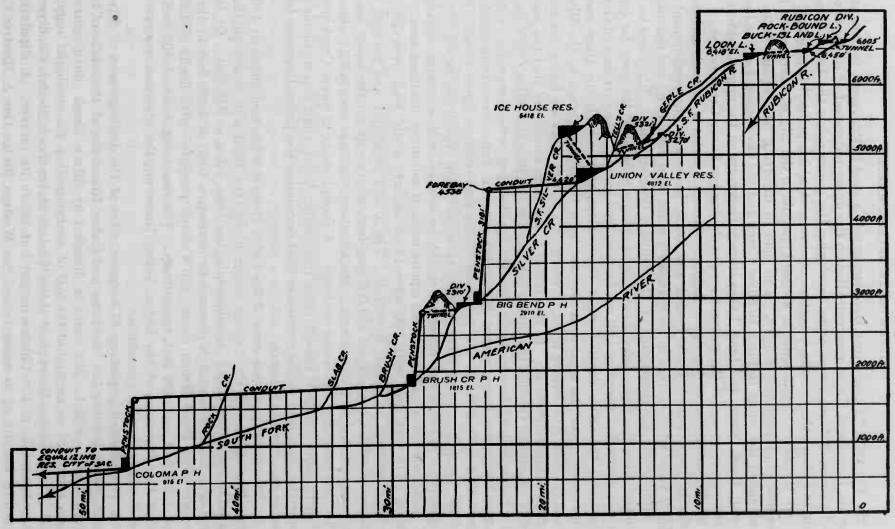
33030–27. (Follow Table 8.)

AMERICAN RIVER REPORT

PLATE V

SILVER CREEK PROJECT WITH DIVERSION FROM RUBICON





SILVER CREEK DEVELOPMENTS

29. The term "Silver Creek developments" is used in this report to designate the Ice House and Union reservoir sites on the upper watershed of Silver Creek and a series of three power drops developing the power below the Union Reservoir and above the Coloma irrigation reservoir, at which point it is proposed to divert the Silver Creek water in a closed conduit to the city of Sacramento for domestic and irrigation supply. The plan of diverting 80.7 square miles of drainage of the upper Rubicon to Silver Creek and the development of the Rock Bound, Buck Island, and Loon Lakes storage reservoirs on the upper Rubicon is also included in one of the schemes for developing the Silver Creek power.

30. The diversion of the upper Rubicon through a series of tunnels and conduits to Buck Island, Rock Bound, and Loon Lakes and the development of 71,000 acre-feet of storage in these reservoirs has been considered and described in detail under the description of the Rubicon developments. The plans up to and including the Loon Lake Reservoir have been considered the same for both developments and therefore will not be described again. The diversion of Gerle Creek and the Little South Fork of the Rubicon at a point below these reservoirs would make the total area diverted from the Rubicon shed to the Silver Creek projects 80.7 square miles, of which 33.7 square miles are below the storage reservoirs referred to. In this report it has been considered that the water would be carried through the divide between the Rubicon and Silver Creek sheds by a concrete-lined tunnel approximately 3 miles long with a capacity of 800 second-feet, which tunnel would deliver the water to Tells Creek, from which it would flow by gravity to the proposed Union Reservoir on Silver Creek. On the Ice House branch of Silver Creek, at an elevation slightly above the Union Reservoir, the Ice House Reservoir would be located, with a storage capacity of 45,000 acre-feet and with 28.4 square miles of tributary drainage area. A tunnel 1,715 feet long with 300 second-feet capacity would lead from the Ice House Reservoir to Union Reservoir. The Union Reservoir was planned in this report with a capacity of 165,000 acre-feet, whether or not the upper Rubicon was diverted to Silver Creek. Its tributary drainage area is 82.7 square miles, not including Ice House drainage. A careful study of Silver Creek project with more accurate run-off data from Silver Creek than was available to the writer, may lead to the conclusion that developing the Union Reservoir to a smaller capacity is advisable.

31. The elevation of the crest of the Union Reservoir has been taken as 4,812 feet. The tailrace of the Coloma power house, the third and lowest contemplated in the Silver Creek developments, has been taken as 915 feet. Of this total drop of 3,897 feet it is planned to develop a total of 3,434 feet in three projects—Big Bend, Brush Creek, and Coloma projects—with heads of 1,627 feet, 1,007 feet, and 800 feet, respectively. The remaining head of 463 feet is lost in the drawdown of the Union Valley Reservoir, the diversion reservoirs, and in the grade of the conduits.

32. It is planned to pick up 57.5 square miles of the drainage area of Silver Creek, which is below the Ice House and Union Reservoirs at the intake of the Brush Creek project. No water is diverted by Silver Creek developments below this point on account of the fear of contaminating the municipal supply.

33. The American River plant of the Western States Gas & Electric Co. diverts below the intake of the Coloma project but above its tailrace. A stipulation signed by the city of Sacramento and the Western States Gas & Electric Co. provides that no natural flow from Silver Creek drainage will be stored above or by-passed around the American River plant when the flow in South Fork of American River at intake of this plant is less than 430 second-feet. The average flow estimated as released by the Silver Creek developments during the

period July, 1911, to January, 1914, to comply with this requirement, was 50 second-feet. (See Table No. 10, column 27.)

34. The city of Sacramento plans to divert eventually all water from the tailrace of its Coloma project to a closed conduit which would conduct it along the south banks of the South Fork of the American River and of the American River to the Sweetwater equalizing reservoir (elevation 765 feet), a distance of 12 miles. Thence the water would be conducted by pipe conduit to the city, a distance of 28 miles. This would prevent the use of the water in what I will term "the Coloma Irrigation Reservoir," which is on the South Fork of the American River at Coloma immediately below the Coloma power-house site of the Silver Creek developments. The elevation of stream bed at the Coloma irrigation dam site is about 600 feet. It is proposed to construct a dam 300 feet high. While this would primarily be an irrigation project, it would be possible to develop seasonal power in the 300-foot maximum head created by the dam. Should this dam be constructed prior to the diversion of the Silver Creek water to Sacramento, the Silver Creek water could be used for power by this project. This matter is discussed further in the description of South Fork developments.

35. A study of the power capacities of the Silver Creek developments has been made under the following assumptions:

1. With diversion of 80.7 miles of Upper Rubicon drainage to Silver Creek developments and water supplied for irrigating Georgetown Ridge by Silver Creek developments: The power capacity available 90 per cent of the time was estimated under these conditions to be 120,000 horsepower (see Table No. 10), the installation as 239,000 horsepower, the total cost as $29,599,000, and the cost per horsepower of capacity available 90 per cent of the time as $247. No credit has been allowed in obtaining these figures for water supplied at tailrace of Coloma power house for irrigation or domestic supply. If this credit is estimated for convenience entirely on an irrigation basis and at $20 per acre irrigated, it would amount to about $1,200,000 on account of the regulated flow of 427 second-feet at Coloma tailrace, supplying about 154,000 acre-feet during a six months' irrigation season, which would irrigate about 60,000 acres. A further credit of $500,000 should be allowed for supplying irrigation water for diversion from Little South Fork of Rubicon to Georgetown Ridge. (See par. 28, assumption 1.)

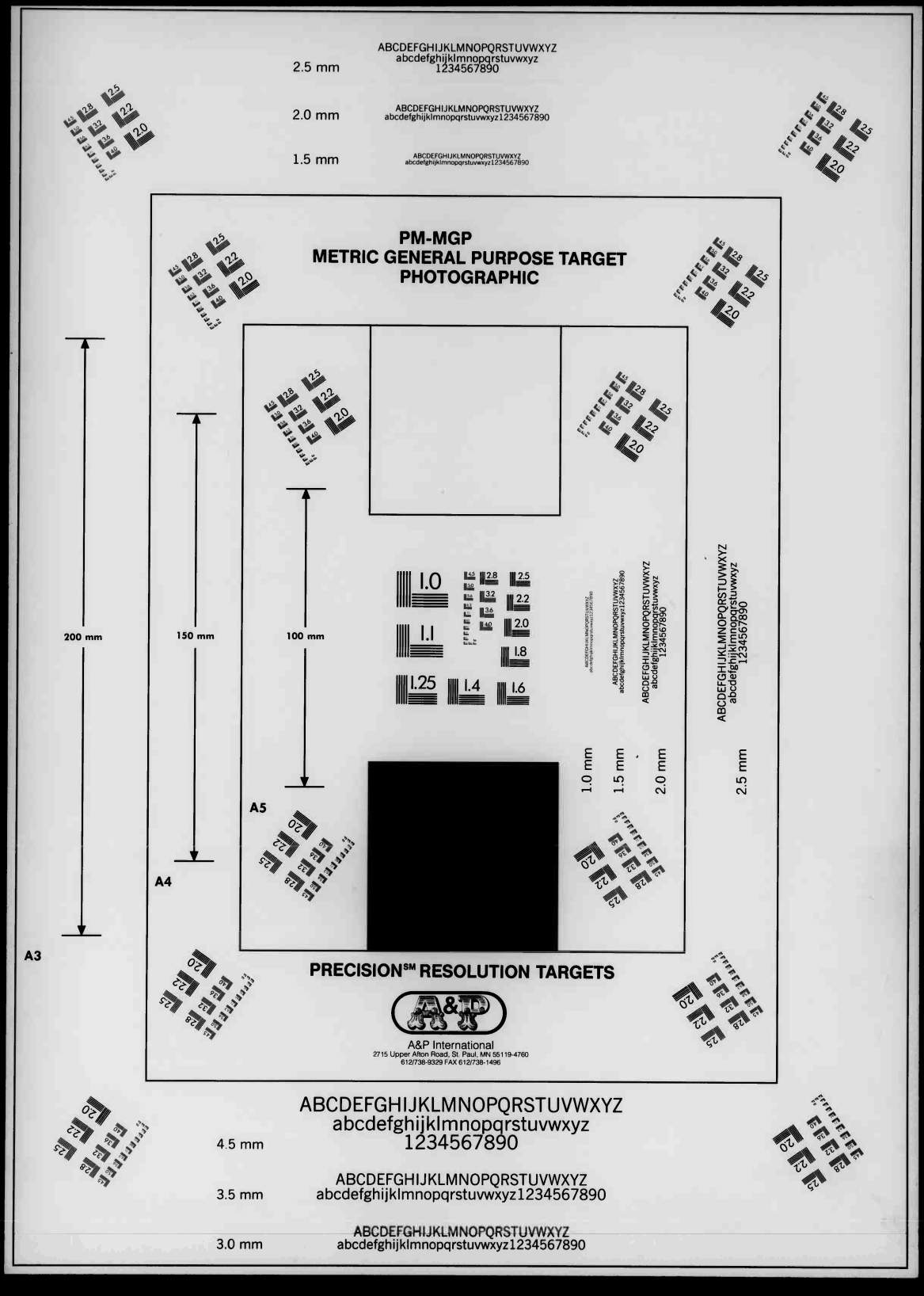
2. With no diversion from Rubicon drainage: The power capacity available 90 per cent of the time was estimated under these conditions to be 79,000 horsepower (see TableNo. 11), the installation as 158,000, the total cost as $19,250,000, and the cost perhorsepower of capacity available 90 per cent of the time as. $244. No credit has been allowed in obtaining these figures for water supplied at tailrace of Coloma power house for irrigation or domestic supply. If this credit is estimated for convenience entirely on an irrigation basis and at $20 per acre irrigated, it would amount to about $800,000 on account of the regulated flow of 268 second-feet at Coloma tailrace, supplying about 112,000 acre-feet during a six months' irrigation season, which would irrigate about 40,000 acres.

36. On account of the possibility of including in the scheme of Silver Creek developments with diversion from Rubicon three power drops between Loon Lake and the Union Reservoir, not included by the city of Sacramento in its application to the Federal Power Commission for preliminary power permit, it would be possible to add 16,000 horsepower available 90 per cent of the time to the total power capacity under assumption No. 1. There follows a description of these three projects. First, project No. 1 of the Rubicon developments, immediately below Loon Lake, could be included, for the reason that the proposed diversion from Rubicon shed to Silver Creek is on Gerle Creek below the tailrace of this project. Second, the Gerle Meadows Reservoir planned under Rubicon developments could be connected by a closed conduit diverting from the reservoir to the left bank of Gerle Creek and continuing for a distance of about 6 miles to a point above the diversion reservoir on Little South Fork Rubicon planned in

Silver Creek developments, where a head, forebay to tailrace, of 525 feet can be developed. Third, it would also be entirely feasible to develop the drop of 269 feet between the outlet of the tunnel through the divide between Rubicon and Silver Creek, elevation 5,081 feet, and the Union Reservoir, elevation 4,812 feet. The distance between the outlet of tunnel (Tells Creek tunnel) and Union Reservoir is about 1½ miles.

37. These projects were not included in estimate of cost of Silver Creek developments, since it was not thought advisable to change the scheme of the city of Sacramento any more than necessary. Their power capacities available 90 per cent of the time are 6,000 horsepower, 7,000 horsepower, and 3,000 horsepower, respectively. Therefore, this total should be added to assumption No. 1 to obtain the ultimate total potential power of Silver Creek developments with diversion from Rubicon. It makes the total capacity available 90 per cent of the time, 136,000 horsepower.

REDUCTION RATIO 13:1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PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC
200 mm
150 mm
100 mm
A3
A4
A5
1.0
1.1
1.25
1.4
1.6
1.8
1.0 mm
1.5 mm
2.0 mm
2.5 mm
PRECISION℠ RESOLUTION TARGETS
A&P International
2715 Upper Afton Road, St. Paul, MN 55119-4760
612/738-9329 FAX 612/738-1496
4.5 mm
ABCDEFGHIJKLMNOPQRSTUVWXYZ
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TABLE No. 10.—*Power capacity, Silver Creek projects with diversion from Rubicon*

Year and month	Total flow into Rock Bound Lake (drainage area, 34 square miles)	Flow into Loon Lake from Loon Lake drainage and 4 square miles Little South Fork Rubicon (0+4=13 square miles)	Total flow into Rock Bound and Loon Lakes	Stored (+) or released (—) Loon Lake Reservoir (capacity, 47,000 acre-feet; area, 1,162 acres)	In Loon Lake and Rock Bound Lake Reservoir (24,000 + 47,000—71,000 acre-feet capacity)	Controlled flow from Loon Lake Reservoir	Flow from Gerle Creek and Little South Fork, Rubicon (total drainage area 33.7 square miles)	Pilot Creek at Bacchis (drainage area, 19 square miles)	Diverted from Pilot Creek at Bacchis for irrigating George-town Ridge	Released for George-town Ridge irrigation	Total flow available for irrigating George-town Ridge	Total flow through tunnel to Union Reservoir (capacity 800 second-feet)	Total flow to Ice House Reservoir (drainage area 28.4 square miles)	Stored (+) or released (—) Ice House Reservoir	In Ice House Reservoir (capacity, 45,000 acre-feet; area, 680 acres)	Flow to Union Reservoir from Ice House (capacity, 300 second-feet)	Flow from Union drainage direct (drainage area, 82.7 square miles)	Total flow to Union Reservoir	Stored (+) or released (—) Union Valley Reservoir	In Union Valley Reservoir (capacity, 165,000 acre-feet; area, 2,100 acres)	Flow to Big Bend power house (capacity conduit, 500 second-feet)	Power developed Big Bend power house (head, 1,627 feet)	Flow from Silver Creek at Brush Creek intake (drainage area, 57.5 square miles)	Total flow to Brush Creek power house (capacity conduit, 900 second-feet)	Power developed Brush Creek power house (head 1,007 feet)	Released to take care of prior rights on South Fork of American River	Total flow to Coloma power house (capacity conduit, 800 second-feet)	Power developed Coloma power house (head, 860 feet)	Total power developed
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1911	*Sec.-ft.*			*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*H. p.*	*H. p.*
July	299	110	409	0	1,183	409	60	12	12	196	208	273	146	0	750	146	261	680	0	680	[1] 762	[2] 48,300	82	762	[2] 38,400	0	762	[2] 38,400	141,400
August	42	16	58	−268	915	335	7	1	1	207	208	126	58	−46	704	104	165	335	−80	255	762	48,300	20	440	23,400	183	257	16,500	106,600
September	6	3	9	−259	676	248	2	7	7	118	125	132	58	−46	658	104	105	341	−79	262	683	43,300	20	440	23,400	183	257	16,500	106,600
1911-12																													
October	5	1	6	−147	[1] 475	153	5	13	13	20	33	138	7	−97	[1] 541	104	13	255	−165	[1] 2,358	420	54,700	5	425	34,200	25	400	25,600	114,500
November	11	4	15	−103	370	201	0	0	17	4	0	4	129	7	−97	455	104	13	246	−174	2,196	420	54,700	16	436	35,100	58	378	24,200	114,600
December	6	3	9	−103	267	112	17	12	4	4	0	4	129	7	−97	358	104	13	246	−174	2,024	420	54,700	10	430	34,600	30	400	25,600	114,900
January	11	4	15	−95	172	110	19	20	4	4	0	4	129	7	−97	358	104	13	246	−174	1,850	420	54,700	21	441	35,500	41	400	25,600	115,800
February	13	4	17	−89	83	106	23	16	4	4	0	4	129	15	−89	169	104	27	260	−160	1,690	420	54,700	21	441	35,500	63	378	24,200	114,400
March	22	9	31	−73	10	104	29	20	8	0	8	133	22	+22	191	0	49	173	−247	1,443	420	54,700	21	441	35,500	63	378	24,200	114,400
April	76	27	103	+67	77	36	97	41	8	0	8	133	148	+148	339	0	266	399	−21	1,422	420	54,700	21	451	36,300	0	451	28,900	119,900
May	367	136	503	+503	580	0	343	77	77	6	83	337	274	+274	613	0	491	928	+408	1,830	420	54,700	78	498	40,100	0	498	31,900	126,700
June	387	143	530	+530	1,110	0	158	27	27	115	142	43	185	+81	694	104	332	479	+59	1,889	420	54,700	171	591	47,600	0	591	37,800	140,100
July	90	33	123	−181	929	314	11	11	11	197	208	128	37	−67	627	104	66	298	−122	1,767	420	54,700	153	553	44,500	0	553	35,400	134,600
August	13	4	17	−306	613	323	2	6	6	202	208	123	15	−80	536	104	27	254	−166	1,601	420	54,700	21	441	35,500	124	317	20,300	110,500
September	17	6	23	−212	401	235	7	9	9	116	125	126	7	−97	441	104	13	243	−177	1,424	420	54,700	5	425	34,200	47	378	24,200	113,100
1912-13																													
October	4	1	5	−141	[1] 206	146	4	6	6	27	33	123	8	−96	[1] 325	104	14	241	−179	[1] 1,182	420	54,700	5	425	34,200	25	400	25,600	114,500
November	56	20	76	+7	213	60	52	21	4	0	4	121	16	−88	237	104	29	254	−166	1,016	420	54,700	6	426	34,300	28	398	25,500	114,500
December	12	4	16	−85	128	101	20	14	4	0	4	121	8	−96	141	104	14	239	−181	835	420	54,700	17	437	35,200	62	375	24,000	113,900
January	15	6	21	−83	45	104	17	20	4	0	4	121	8	−96	45	104	14	239	−181	654	420	54,700	11	431	34,700	33	398	25,500	114,900
February	34	13	47	−38	7	85	36	18	4	0	4	121	16	−45	0	61	29	211	−209	445	420	54,700	22	442	35,600	44	398	25,500	115,800
March	52	19	71	−2	5	73	62	26	8	0	8	125	24	0	0	24	43	192	−228	217	420	54,700	22	442	35,600	67	375	24,000	114,300
April	193	78	271	+253	258	18	207	94	8	0	8	225	160	+160	160	0	286	511	+91	308	420	54,700	33	453	36,500	0	453	30,900	121,200
May	461	170	631	+631	889	0	333	47	47	36	83	297	294	+294	454	0	538	825	+465	773	420	54,700	83	503	40,500	0	503	32,200	127,400
June	263	90	353	+294	1,183	39	108	21	21	121	142	21	198	+198	652	0	357	378	−42	671	420	54,700	183	603	48,300	0	603	38,400	141,400
July	83	30	113	−222	961	335	19	8	8	200	208	154	40	−86	566	126	71	351	−69	602	420	54,700	145	565	45,500	0	565	36,200	136,400
August	23	9	32	−317	644	349	5	6	6	202	208	152	16	−110	456	126	29	307	−113	489	420	54,700	22	442	35,600	133	309	19,800	110,100
September	4	1	5	−263	381	208	3	5	5	120	125	151	8	−118	338	126	14	291	−129	360	420	54,700	6	426	34,300	51	375	24,000	113,000
1913-14																													
October	1	0	1	−176	[1] 151	177	2	6	6	27	33	152	20	−106	[1] 212	126	37	315	−105	[1] 192	420	54,700	14	434	35,000	71	361	23,200	112,900
November	9	3	12	−128	23	140	10	15	4	0	4	150	41	−85	127	126	74	330	−70	122	420	54,700	57	477	38,400	172	305	19,500	112,600
December	34	13	47	−19	4	66	84	42	4	0	4	150	20	−106	21	126	37	313	−107	15	420	54,700	29	449	36,200	86	363	23,200	114,100
January	126	46	172	+172	176	0	144	286	4	0	4	144	347	+221	242	126	622	992	+472	487	420	54,700	242	662	48,300	0	662	38,400	141,400
Total	2,715	1,006	3,721			4,566	1,889	924	338	1,910	2,248	4,536	2,225			2,673	3,997	11,206			13,280	1,695,700	1,537	14,817	1,174,700	1,554	13,263	835,600	3,706,000
Mean	87	32	120			147	60	29	10	61	72	146	71			86	129	361			428	54,700	49	478	37,893	50	427	26,954	119,500

[1] Evaporation is taken care of by deducting the total estimated evaporation from each reservoir on Oct. 1 of each year. Evaporation is estimated at each reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.
[2] Installed capacities o Big Bend, Brush Creek, and Coloma power houses are 110,000, 75,000, and 54,000 horsepower, respectively. Therefore the maximum average output for any month has been taken as 54,700, 48,300, and 38,400 horsepower, respectively.
The estimated evaporations are as follows: (1) Rock Bound and Loon Lakes, 35 second-feet-months; (2) Ice House Reservoir, 20 second-feet-months; (3) Union Valley Reservoir, 63 second-feet-months.

REDUCTION RATIO 10:1

PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC

150 mm

100 mm

A5

A4

1.0

1.1

1.25

1.4

1.6

1.8

2.0

2.2

2.5

2.8

3.2

3.6

4.0

4.5

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ
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ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890

1.0 mm

1.5 mm

2.0 mm

2.5 mm

PRECISION℠ RESOLUTION TARGETS

A&P International
2715 Upper Afton Road, St. Paul, MN 55119-4760
612/738-9329 FAX 612/738-1496

TABLE No. 10.—*Power capacity, Silver Creek projects with diversion from Rubicon*

Year and month	Total flow into Rock Bound Lake (drainage area, 34 square miles)	Flow into Loon Lake from Loon Lake drainage and 4 square miles Little South Fork Rubicon (9+4=13 square miles)	Total flow into Rock Bound and Loon Lakes	Stored (+) or released (−) Loon Lake Reservoir (capacity, 47,000 acre-feet; area, 1,162 acres)	In Loon Lake and Rock Bound Lake Reservoir (24,000 + 47,000=71,000 acre-feet capacity)	Controlled flow from Loon Lake Reservoir	Flow from Gerle Creek and Little South Fork, Rubicon (total drainage area 33.7 square miles)	Pilot Creek at Bacchis (drainage area, 19 square miles)	Diverted from Pilot Creek at Bacchis for irrigating Georgetown Ridge	Released for Georgetown Ridge irrigation	Total flow available for irrigating Georgetown Ridge	Total flow through tunnel to Union Reservoir (capacity) 800 second-feet)	Total flow to Ice House Reservoir (drainage area 28.4 square miles)	Stored (+) or released (−) Ice House Reservoir	In Ice House Reservoir (capacity, 45,000 acre-feet; area, 680 acres)	Flow to Union Reservoir from Ice House (capacity, 300 second-feet)	Flow from Union drainage direct (drainage area, 82.7 square miles)	Total flow to Union Reservoir	Stored (+) or released (−) Union Valley Reservoir	In Union Valley Reservoir (capacity, 165,000 acre-feet; area, 2,100 acres)	Flow to Big Bend power house (capacity conduit, 500 second-feet)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1911	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*
July	299	110	409	0	1,183	409	60	12	12	196	208	273	146	0	750	146	261	680	0	2,750	680
August	42	16	58	−268	915	326	7	1	1	207	208	126	58	−46	704	104	105	335	−85	2,765	420
September	6	3	9	−239	676	248	2	7	7	118	125	132	58	−46	658	104	105	341	−79	2,886	420
1911–12																					
October	5	1	6	−147	[1] 475	153	5	13	13	20	33	138	7	−97	[1] 541	104	13	255	−165	[1] 2,358	420
November	11	4	15	−105	370	201	9	17	4	0	4	129	15	−89	452	104	27	260	−160	2,196	420
December	6	3	9	−103	267	112	17	12	4	0	4	129	7	−97	355	104	13	246	−174	2,024	420
January	11	4	15	−95	172	110	19	20	4	0	4	129	7	−97	258	104	13	246	−174	1,850	420
February	13	4	17	−89	83	106	23	16	4	0	4	129	15	−89	169	104	27	260	−160	1,690	420
March	22	9	31	−73	10	104	29	20	8	0	8	133	22	+22	191	0	40	173	−247	1,443	420
April	76	27	103	+67	77	36	97	41	8	0	8	133	148	+148	339	0	266	399	−21	1,422	420
May	367	136	503	+503	580	0	343	77	77	6	83	337	274	+274	613	0	491	828	+408	1,830	420
June	387	143	530	+530	1,110	0	158	27	27	115	142	43	185	+81	694	104	332	479	+59	1,889	420
July	90	33	123	−191	919	314	11	11	11	197	208	128	37	−67	627	104	66	298	−122	1,767	420
August	13	4	17	−306	613	323	2	6	6	202	208	123	15	−89	538	104	27	254	−166	1,601	420
September	17	6	23	−212	401	235	7	9	9	116	125	126	7	−97	441	104	13	243	−177	1,424	420
1912–13																					
October	4	1	5	−141	[1] 206	146	4	6	6	27	33	123	8	−96	[1] 325	104	14	241	−179	[1] 1,182	420
November	56	20	76	+7	213	69	52	21	4	0	4	121	16	−88	237	104	29	254	−166	1,016	420
December	12	4	16	−85	128	101	20	14	4	0	4	121	8	−96	141	104	14	239	−181	835	420
January	15	6	21	−83	45	104	17	20	4	0	4	121	8	−96	45	104	14	239	−181	654	420
February	34	13	47	−38	7	85	36	18	4	0	4	121	16	−45	0	61	29	211	−209	445	420
March	52	19	71	−2	5	73	52	26	8	0	8	125	24	0	0	24	43	192	−228	217	420
April	193	78	271	+253	258	18	207	94	8	0	8	225	160	+160	160	0	286	511	+91	308	420
May	461	170	631	+631	889	0	333	47	47	36	83	297	294	+294	454	0	528	825	+405	713	420
June	243	90	333	+294	1,183	39	103	21	21	121	142	21	198	+198	652	0	357	378	−42	671	420
July	83	30	113	−222	961	335	19	8	8	200	208	154	40	−86	566	126	71	351	−69	602	420
August	23	9	32	−317	644	349	5	6	6	202	208	152	16	−110	456	126	29	307	−113	489	420
September	4	1	5	−263	381	268	3	5	5	120	125	151	8	−118	338	126	14	291	−129	360	420
1913–14																					
October	1	0	1	−176	[1] 151	177	2	6	6	27	33	152	20	−106	[1] 212	126	37	315	−105	[1] 192	420
November	9	3	12	−128	23	140	10	15	4	0	4	150	41	−85	127	126	74	350	−70	122	420
December	34	13	47	−19	4	66	84	42	4	0	4	150	20	−106	21	126	37	313	−107	15	420
January	126	46	172	+172	176	0	144	286	4	0	4	144	347	+221	242	126	622	892	+472	487	420
Total	2,715	1,006	3,721	----------	----------	4,566	1,880	924	338	1,910	2,248	4,536	2,225	----------	----------	2,673	3,997	11,206	----------	----------	13,280
Mean	87	32	120	----------	----------	147	60	29	10	61	72	146	71	----------	----------	86	129	361	----------	----------	428

[1] Evaporation is taken care of by deducting the total estimated evaporation from each reservoir on Oct. 1 of each year. Evaporation is estimated at each reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.

[2] Installed capacities of Big Bend, Brush Creek, and Coloma power houses are 110,000, 75,000, and 54,000 horsepower, respectively. Therefore the maximum average output for any month has been taken as 54,700, 48,300, and 38,400 horsepower, respectively. The estimated evaporations are as follows: (1) Rock Bound and Loon Lakes, 35 second-feet-months; (2) Ice House Reservoir, 20 second-feet-months; (3) Union Valley Reservoir, 63 second-feet-months.

TABLE No. 10.—*Power capacity, Silver Creek projects with diversion from Rubicon*

Flow from Gerle Creek and Little South Fork, Rubicon (total drainage area 33.7 square miles)	Pilot Creek at Bacchis (drainage area, 19 square miles)	Diverted from Pilot Creek at Bacchis for irrigating Georgetown Ridge	Released for Georgetown Ridge irrigation	Total flow available for irrigating Georgetown Ridge	Total flow through tunnel to Union Reservoir (capacity) 800 second-feet)	Total flow to Ice House Reservoir (drainage area 28.4 square miles)	Stored (+) or released (−) Ice House Reservoir	In Ice House Reservoir (capacity, 45,000 acre-feet; area, 680 acres)	Flow to Union Reservoir from Ice House (capacity, 300 second-feet)	Flow from Union drainage direct (drainage area, 82.7 square miles)	Total flow to Union Reservoir	Stored (+) or released (−) Union Valley Reservoir	In Union Valley Reservoir (capacity, 165,000 acre-feet; area, 2,100 acres)	Flow to Big Bend power house (capacity conduit, 500 second-feet)	Power developed Big Bend power house (head, 1,627 feet)	Flow from Silver Creek at Brush Creek intake (drainage area, 57.5 square miles)	Total flow to Brush Creek power house (capacity conduit, 900 second-feet)	Power developed Brush Creek power house (head 1,007 feet)	Released to take care of prior rights on South Fork of American River	Total flow to Coloma power house (capacity conduit, 800 second-feet)	Power developed Coloma power house (head, 800 feet)	Total power developed
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.-mo.*	*Sec.-ft.-mo.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*H. p.*	*Sec.-ft.*	*Sec.-ft.*	*H. p.*	*H. p.*
60	12	12	196	208	273	146	0	750	146	261	680	0	2,750	680	[2] 54,700	82	762	[2] 48,300	0	762	[2] 38,400	141,400
7	1	1	207	208	126	58	−46	704	104	105	335	−85	2,765	420	54,700	20	440	35,400	183	257	16,500	106,600
2	7	7	118	125	132	58	−46	658	104	105	341	−79	2,686	420	54,700	20	440	35,400	183	257	16,500	106,600
5	13	13	20	33	138	7	−97	[1] 541	104	13	255	−165	[1] 2,358	420	54,700	5	425	34,200	25	400	25,600	114,500
9	17	4	0	4	129	15	−89	452	104	27	260	−160	2,196	420	54,700	16	436	35,100	58	378	24,200	114,000
17	12	4	0	4	129	7	−97	355	104	13	246	−174	2,024	420	54,700	10	430	34,600	30	400	25,600	114,900
19	20	4	0	4	129	7	−97	258	104	13	246	−174	1,850	420	54,700	21	441	35,500	41	400	25,600	115,800
23	16	4	0	4	129	15	−89	169	104	27	260	−160	1,690	420	54,700	21	441	35,500	63	378	24,200	114,400
29	20	8	0	8	133	22	+22	191	0	40	173	−247	1,443	420	54,700	31	451	36,300	0	451	28,900	119,900
97	41	8	0	8	133	148	+148	339	0	266	399	−21	1,422	420	54,700	78	498	40,100	0	498	31,900	126,700
343	77	77	6	83	337	274	+274	613	0	491	828	+408	1,830	420	54,700	171	591	47,600	0	591	37,800	140,100
158	27	27	115	142	43	185	+81	694	104	332	479	+59	1,889	420	54,700	133	553	44,500	0	553	35,400	134,600
11	11	11	197	208	128	37	−67	627	104	66	298	−122	1,767	420	54,700	21	441	35,500	124	317	20,300	110,500
2	6	6	202	208	123	15	−89	538	104	27	254	−166	1,601	420	54,700	5	425	34,200	47	378	24,200	113,100
7	9	9	116	125	126	7	−97	441	104	13	243	−177	1,424	420	54,700	5	425	34,200	25	400	25,600	114,500
4	6	6	27	33	123	8	−96	[1] 325	104	14	241	−179	[1] 1,182	420	54,700	6	426	34,300	28	398	25,500	114,500
52	21	4	0	4	121	16	−88	237	104	29	254	−166	1,016	420	54,700	17	437	35,200	62	375	24,000	113,900
20	14	4	0	4	121	8	−96	141	104	14	239	−181	835	420	54,700	11	431	34,700	33	398	25,500	114,900
17	20	4	0	4	121	8	−96	45	104	14	239	−181	654	420	54,700	22	442	35,600	44	398	25,500	115,800
36	18	4	0	4	121	16	−45	0	61	29	211	−209	445	420	54,700	22	442	35,600	67	375	24,000	114,300
52	26	8	0	8	125	24	0	0	24	43	192	−228	217	420	54,700	33	453	36,500	0	453	30,000	121,200
207	94	8	0	8	225	160	+160	160	0	286	511	+91	308	420	54,700	83	503	40,500	0	503	32,200	127,400
333	47	47	36	83	297	294	+294	454	0	529	825	+405	713	420	54,700	183	603	48,300	0	603	38,400	141,400
103	21	21	121	142	21	198	+198	652	0	357	378	−42	671	420	54,700	145	565	45,500	0	565	36,200	136,400
19	8	8	200	208	154	40	−86	566	126	71	351	−69	602	420	54,700	22	442	35,600	133	309	19,800	110,100
5	6	6	202	208	152	16	−110	456	126	29	307	−113	489	420	54,700	6	426	34,300	51	375	24,000	113,000
3	5	5	120	125	151	8	−118	338	126	14	291	−129	360	420	54,700	6	426	34,300	28	398	25,500	114,500
2	6	6	27	33	152	20	−106	[1] 212	126	37	315	−105	[1] 192	420	54,750	14	434	35,000	71	363	23,200	112,900
10	15	4	0	4	150	41	−85	127	126	74	350	−70	122	420	54,700	57	477	38,400	172	305	19,500	112,600
84	42	4	0	4	150	20	−106	21	126	37	313	−107	15	420	54,700	29	449	36,200	86	363	23,200	114,100
144	286	4	0	4	144	347	+221	242	126	622	892	+472	487	420	54,700	242	662	48,300	0	662	38,400	141,400
1,880	924	338	1,910	2,248	4,536	2,225	----------	----------	2,673	3,997	11,206	----------	----------	13,280	1,695,700	1,537	14,817	1,174,700	1,554	13,263	[3] 35,600	3,706,000
60	29	10	61	72	146	71	----------	----------	86	129	361	----------	----------	428	54,700	49	478	37,893	50	427	26,954	119,500

[1] of each year. Evaporation is estimated at each reservoir as 3 feet in depth on 60 per cent of the maximum area of the reservoir.
[2] horsepower, respectively. Therefore the maximum average output for any month has been taken as 54,700, 48,300, and 38,400 horsepower, respectively.
[3] (2) Ice House Reservoir, 20 second-feet-months; (3) Union Valley Reservoir, 63 second-feet-months.

TABLE No. 11.—*Power capacity, Silver Creek projects, without diversion from Rubicon*

Big Bend project:		
Total flow in second-feet-months from Aug., 1911, to Dec., 1913, to Ice House (see column 14, Table 10)		1,732
In Ice House Reservoir at beginning of period		750
Total flow in second-feet-months from Aug., 1911, to Dec., 1913, from area tributary direct to Union (see column 18, Table 10)		3,114
In Union Reservoir at beginning of period		2,750
Total		8,346
Three years' evaporation in Ice House and Union Reservoirs		249
Net available during 29 months	second-feet-months	8,097
Mean flow per month	second-feet	279
Mean power developed at Big Bend power house for period, 1,627 x 0.08 x 279	horsepower	36,000
Brush Creek project:		
Total flow in second-feet-months from Aug., 1911, to Dec., 1913, from area below Big Bend intake and above Brush Creek intake (see column 24, Table 10)		1,213
Total net flow to Big Bend same period (see above)		8,097
Total net flow to Brush Creek for 29 months	second-feet-months	9,310
Mean flow per month	second-feet	321
Mean power developed at Brush Creek power house for period, 1,007 x 0.08 x 321	horsepower	26,000
Coloma project:		
Mean flow Aug., 1911, to Dec., 1913, at Brush Creek power house (see above)	second-feet	321
Mean flow, same period, released to satisfy rights of Western States Gas & Electric Co. (see column 27, Table 10)	second-feet	53
Mean flow per month	do	268
Mean power developed at Coloma power house, 800 x 0.08 x 268	horsepower	17,000
Summary:		
Big Bend	do	36,000
Brush Creek	do	26,000
Coloma	do	17,000
Total	do	79,000

SOUTH FORK DEVELOPMENTS

38. The term "South Fork Developments" is used in this report to designate projects developing the power possibilities along the South Fork of the American River proper. No Silver Creek projects are included.

39. The power possibilities on the South Fork of the American River proper lie between the mouth of Strawberry Creek (elevation 5,600 feet) and the backwater from the Folsom Dam (elevation 210 feet). The total distance along the stream is approximately 64 miles, and the total fall about 5,400 feet, or somewhat less than 100 feet per mile. The stream has a fall of approximately 4,500 feet for the first 34 miles, the fall in the remaining 30 miles being only 900 feet. Along this 64 miles of stream there are two developed projects, both owned or controlled by the Western States Gas & Electric Co., the upper one being known as the El Dorado plant and the lower as the American River plant. It would require four or five more projects to develop completely the power drop on the South Fork proper. There is also one power possibility on the Silver Fork. The drop of all the projects, except one, would be developed by long conduits, the one exception being the Coloma irrigation resevoir, where the drop would be developed by a dam 300 feet high, which could also be used for developing seasonal power under a variable head.

40. The total storage planned by the Western States Gas & Electric Co. above its El Dorado plant is 99,000 acre-feet, of which 32,000 acre-feet is now impounded. Of this possible storage, 18,000 acre-feet is on the headwaters of the American River proper above elevation 6,000 feet; about 50,000 acre-feet is on Silver Fork (not to be confused with Silver Creek), which joins the main stream at intake of the El Dorado project; and the remainder is on Plum and Alder Creeks, also tributary to this project.

41. The South Fork of American River is joined by the Silver Fork at elevation approximately 3,900 feet. This fork has about the same drainage area as the main stream at the junction point.

42. It is believed that a project developing the drop on the South Fork of the American River above the El Dorado project will ultimately be feasible. It would divert immediately below Strawberry Creek at an approximate elevation of 5,600 feet, and there would be tributary to it 49 square miles of drainage area and 18,000 acre-feet of storage planned by the Western States Gas & Electric Co. A conduit 8 miles long would develop about 1,500 feet, forebay to tailrace, of power drop, the water being returned to the South Fork at the intake of the El Dorado plant, the elevation of which is about 3,925 feet. It is estimated that the controlled flow during periods of low run-off would be about 36 second-feet, and the capacity available 90 per cent of the time 4,000 horsepower.

43. The power on Silver Fork would most likely be developed by diverting at about elevation 5,600 feet into a conduit which would be 7 miles long. The power house would be located on South Fork at mouth of Silver Fork, returning the water at about elevation 3,925 feet. The head, forebay to tailrace, would be about 1,500 feet. The drainage area tributary to the project is 48 square miles. It is estimated that the regulated stream flow available during periods of low run-off would be 86 second-feet. There is 50,000 acre feet of storage either constructed or planned on Silver Fork above the project. The power capacity available 90 per cent of the time is roughly estimated as 10,000 horsepower.

44. The El Dorado project of the Western States Gas & Electric Co. diverts from the South Fork at a point just below the mouth of Silver Fork approximately 8 miles below the mouth of Strawberry Creek and at elevation approximately 3,925 feet. There are 190 square miles of tributary drainage area. The conduit is on the left or south bank of the South Fork. It is almost entirely lined either with concrete or planks and has a present capacity of 120 second-feet. It is planned to complete the lining with concrete and ultimately to increase the capacity to 350 second-feet by raising the sides. The power house is located on the left bank of the South Fork, returning the water to the South Fork at a point approximately 1 mile below the mouth of Silver Creek. The tailrace water elevation is approximately 1,887 feet and the static head about 1,905 feet. The present installation is 21,500 horsepower and the ultimate installation planned is 107,500 horsepower. The controlled flow with ultimate storage through periods of low run-off is estimated as about 168 second-feet. The conduit of this project is obligated to supply a maximum flow of 40 second-feet and an annual total of 15,000 acre-feet for the irrigation of lands on the ridge between the South Fork of the American River and the Cosumnes River, which water is not available for power use in this plant. This leaves a power flow of 128 second-feet. The power capacity available 90 per cent of the time would therefore be about 20,000 horsepower.

45. The intake of the American River plant, the lower project of the Western States Gas & Electric Co., is located on the South Fork at elevation 1,710 feet, at a point approximately 5 miles below the tailrace of their upper project. The undeveloped head between the two plants is therefore about 177 feet. This drop may be ultimately developed by a conduit, or a conduit and storage dam, picking up the unregulated flow from the American River as well as getting the regulated flow from the El Dorado plant. It is estimated roughly that the controlled flow during periods of low run-off, taking advantage of the regulation afforded by the ultimate storage reservoirs of the Western States Gas & Electric Co., will be 140 second-feet, and that the 90 per cent of-the-time capacity will be approximately 2,000 horsepower. The Silver Creek developments would by-pass all stored Silver Creek water around this project.

46. The lower project of the Western States Gas & Electric Co. diverts from the South Fork of the American River at elevation 1,710 feet, at a point 6 miles below the mouth of Silver Creek and about 3 miles below the proposed intake of the Coloma project of the Silver Creek developments, as planned by the city of Sacramento. The tributary drainage area is 494 square miles. The conduit is 7 miles long and is reported to have a capacity of 140 second-feet. The Western States Gas & Electric Co. claims a perfected water right of 150 second-feet and a valid water filing of 280 second-feet additional. These rights have been recognized by stipulation agreed to between the city of Sacramento and the Western States Gas & Electric Co. on December 6, 1923. This makes the total right of this plant 430 second-feet in so far as can now be determined. Estimates of power capacity of Silver Creek developments have been based on the plan of releasing natural flow from Silver Creek below the Brush Creek power house at times when the flow of the South Fork of the American River is less than 430 second-feet. It will be necessary for the company to enlarge the conduit and installation at this plant to take advantage of a flow greater than 150 second-feet. This plant also receives a small supply of water from Slab Creek through the Summerfield ditch, which is 20 miles long and has a capacity of 7.5 second-feet. This supply is delivered through the Finnon Reservoir, which is located on the north bank of the South Fork almost directly above the power house. This reservoir has a capacity of 600 acre-feet. Some of the Summerfield ditch water is used for irrigation.

47. This lower plant of the Western States Gas & Electric Co. returns water to the American River at approximate elevation 1,095 feet. The static head, forebay to tailrace, is 572 feet. The installation in the power house is 6,500

horsepower. The controlled flow, with all storage planned through periods of low run-off, is estimated roughly as 170 second-feet and the 90 per cent of-the-time capacity as 8,000 horsepower.

48. There is a drop of 295 feet in the 6 miles of the South Fork of the American River below the lower Western States Gas & Electric Co.'s plant and above the backwater of the Coloma irrigation reservoir, the proposed maximum elevation of which is 900 feet. A project developing this drop would have a flow partly regulated by the projects of the Western States Gas & Electric Co. above. It is estimated roughly that the regulated flow during periods of low run-off would be 180 second-feet and that the capacity available 90 per cent of the time would be 4,000 horsepower.

TABLE No. 12.—*Run-off, South Fork American River, near Placerville*

(Drainage area, 612.5 square miles)

Year	Run-off		Year	Run-off	
	November to May	June to October		November to May	June to October
	Acre-feet	*Acre-feet*		*Acre-feet*	*Acre-feet*
1904–5	531,480	137,000	1915–16	964,260	281,000
1905–6	1,041,000	608,000	1916–17	696,000	345,000
1906–7	1,410,720	483,000	1917–18	454,680	129,000
1907–8	380,840	128,000	1918–19	539,300	70,000
1908–9	1,033,740	305,000	1919–20	423,120	124,000
1909–10	914,160	117,000	1920–21	713,640	259,000
1910–11	1,257,660	581,000	1921–22	807,480	
1911–12	292,860	172,000			
1912–13	393,480	109,000	Total	13,652,060	4,416,000
1913–14	1,016,220	280,000			
1914–15	681,420	290,000	Mean	758,000	260,000

Mean annual run-off, 1,018,000 acre-feet.

49. The Coloma irrigation reservoir (not to be confused with the Coloma project of the Silver Creek developments, so named by the city of Sacramento) would be impounded by a 300-foot dam on the South Fork of the American River 5 miles below the town of Coloma. No accurate surveys of the site are available. The storage capacity estimated from United States Geological Survey topographical sheet is from 300,000 to 500,000 acre-feet. This reservoir could be used to reregulate the flow of the South Fork for the benefit of irrigation. The average annual run-off of the South Fork at the Chili Bar gauging station is 1,018,000 acre-feet (see Table No. 12), of which 758,000 acre-feet comes during the seven months from November to May, inclusive. The total flow during these seven months was less than 500,000 acre-feet for five seasons in the 18 years of record. The flow for these five seasons was 380,000, 292,000, 393,000, 454,000, and 423,000 acre-feet. It is therefore evident that this reservoir has only a slightly greater capacity than can be filled each year. The diversion of 80.7 square miles of the upper Rubicon drainage to Silver Creek projects would supply annually an additional 102,000 acre-feet, of which 68,000 acre-feet would be during the seven months, November to May, inclusive. The Coloma Reservoir project is covered by a permit from the Federal Power Commission under project No. 307.[1] In a report to the commission, by Engineer R. R. Randell under date of August 31, 1922, the power capacity available 90 per cent of the time was estimated as 16,000 horsepower and the average head as 230 feet.

[1] This permit expired May 8, 1924.—EDITOR.

50. Following is a summary of the power capacity available 90 per cent of the time of projects constructed and proposed, developing the power possibilities of the South Fork of the American River:

	Drop	Flow	Capacity
	Feet	*Sec.-ft.*	*Horse-power*
1. South Fork from Strawberry Creek to Silver Fork	1,500	36	4,000
2. On Silver Fork	1,500	86	10,000
3. Western States Gas & Electric Co.'s El Dorado project	1,905	128	20,000
4. South Fork between power house El Dorado project and intake American River project	177	140	2,000
5. Western States Gas & Electric Co.'s American River project	572	170	8,000
6. South Fork between American River power house and Coloma irrigation reservoir	295	180	4,000
7. Coloma irrigation reservoir project	230		16,000
Total			64,000

AMERICAN RIVER DEVELOPMENTS BELOW BRANCHES

51. The elevation of the American River at the mouth of the South Fork is approximately 210 feet. The high-water elevation at Sacramento is approximately 29 feet. The fall in this 20 miles of stream is therefore about 181 feet. The only possible power development in this stretch of the river is the Folsom plant of the Pacific Gas & Electric Co. This project is located on the stream approximately 2 miles below the mouth of the South Fork. The elevation of the crest of the dam is 210 feet. The elevation of the river below the plant is 120 feet. The dam and part of the conduit are on a narrow strip of land between the grounds of the State penitentiary at Folsom and the American River. The State utilizes a drop of 7.33 feet in the canal for developing mechanical power in the prison. The plant of the Pacific Gas & Electric Co. develops a drop of 55 feet below this, with an installation of 4,000 horsepower. The remainder of the drop to elevation 120 feet was formerly utilized by a second plant of the power company, but it is now obsolete and not in operation. The conduit capacity is 1,200 second-feet and the power company claims a right to the natural flow up to this amount.

52. The Folsom Dam is well located for diverting the American River into irrigation conduits which would have a sufficient elevation to supply lands by gravity between the foothills and the Sacramento River. If the Folsom Dam were raised 40 feet to crest elevation of 250 feet, which seems entirely feasible, and irrigation conduits were to take off at elevation 220 feet, there would be available a 30-foot drawdown which, it is roughly estimated, would make available about 20,000 acre-feet of storage. A dam of this height would back the water up the stream approximately 5 miles.

53. It is estimated that conduits diverting at this point would ultimately have a safe irrigation supply, when all known feasible irrigation reservoirs on the American River are developed, for about 400,000 acres, which is based on the following data and on allowing a gross supply of 2.5 acre-feet per acre:

	Acre-feet
Supply from South Fork of the American River during irrigation season, with storage of 300,000 acre-feet in Coloma irrigation reservoir; includes all water from South Fork except Silver Creek	300,000
Regulated flow from Silver Creek developments without diversion from Rubicon, 268 second-feet, equivalent during six months' irrigation season to (No deduction made for domestic supply.)	96,000
Regulated flow from Rubicon developments, 365 second-feet, equivalent during six months' irrigation season to (See Table No. 8, column 33.)	131,000

	Acre-feet
Regulated flow from Middle Fork power developments, including diversion from the North Fork and regulation, 247 second-feet, equivalent during six months' irrigation season to (See Table No. 5, project No. 2.)	89,000
Supply from North and Middle Forks of American River stored in possible irrigation reservoir of 400,000 acre-feet capacity on lower North and Middle Forks	400,000
Total	1,016,000

In making the above estimate it was not practicable to consider water already used for irrigation. The above is probably a rough approximation of the total area that can be irrigated by the stream from the Folsom diversion.

GENERAL SUMMARY OF POWER CAPACITIES AND COSTS

54. It is believed that the diversion of Rubicon water to French Meadows on Middle Fork can be dropped from further consideration because it means a total development on Middle Fork and Rubicon combined of only 114,000 horsepower, whereas they will develop 45,000 and 99,000 each, respectively, with no diversions from or to either shed.

55. The diversion of the upper North Fork to French Meadows is believed to be a better plan than diverting Middle Fork below French Meadows to North Fork because the Middle Fork No. 3 project, with intake below the Rubicon will be benefited by storage from Rubicon. This will make the development of the entire drop from French Meadows to the intake of North Fork ditch below mouth of Middle Fork much more feasible than would be the case if the French Meadows storage were diverted to North Fork and the power projects all located along the North Fork and getting no benefit from Rubicon storage.

56. It was shown under the description of Middle Fork developments that there would be a gain in power caused by diverting the upper North Fork to the French Meadows Reservoir over developing projects on the North Fork without diversion on account of the regulation afforded by the French Meadows Reservoir.

57. There remain, therefore, only two alternatives for further consideration, in both of which the upper North Fork would be diverted to French Meadows.

(1) Diversion of upper Rubicon to Silver Creek developments with Silver Creek developments supplying irrigation demand of Georgetown Ridge.

(2) No diversion from upper Rubicon with Rubicon developments supplying irrigation requirements of Georgetown Ridge.

In the following tabulations no credit is given for irrigation water:

Alternative No. 1.—Without irrigation credit

Project	90 per cent time power	Installed	Estimated cost	Cost per horsepower
	Horsepower	*Horsepower*		
Middle Fork developments	80,000	162,000	$20,120,000	$252
Rubicon developments	37,000	80,000	7,960,000	215
Silver Creek developments	120,000	239,000	29,599,000	247
Total	237,000	481,000	57,679,000	243
Addition to Silver Creek power on account of Rubicon development No. 1, and of project developing drop between Gerle Meadows Reservoir and intake of Tells Creek tunnel, and project developing drop between outlet Tells Creek tunnel and Union Reservoir (not included in application of city of Sacramento but ultimately feasible under above alternative)	16,000	32,000	2,500,000	
Ultimate capacity	253,000	513,000	60,179,000	238

Alternative No. 2.—Without irrigation credit

Project	90 per cent time power	Installed	Estimated cost	Cost per horsepower
	Horsepower	*Horsepower*		
Middle Fork developments	86,000	174,000	$21,250,000	$247
Rubicon developments	99,000	212,000	20,509,000	207
Silver Creek developments	79,000	158,000	19,250,000	244
Total	264,000	544,000	61,009,000	231

58. In order to put the projects on a more comparable basis, a credit has been given in the two following tabulations for water made available in American River either at Folsom Dam, Coloma tailrace, or in Loon Lake Reservoir at the rate of $20 for a supply sufficient to irrigate one acre whether water would be used for irrigation or domestic supply.

Alternative No. 1.—With irrigation credit

Project	90 per cent time power	Estimated cost	Water supply for—		Irrigation credit	Remaining cost charged against power	Cost per horsepower
			Sacramento Valley	Georgetown Ridge			
	Horsepower		*Acres*	*Acres*			
Middle Fork developments	80,000	$20,120,000	[1]36,000	0	$720,000	$19,400,000	$243
Rubicon developments	37,000	7,960,000	[1]26,000	0	520,000	7,440,000	201
Silver Creek developments including 3 additional plants not included in application of city of Sacramento	136,000	32,099,000	[1]62,000	25,000	1,740,000	30,359,000	223
Total	253,000	60,179,000	124,000	25,000	2,980,000	57,199,000	226

[1] Irrigation computed on basis of controlled flow from power plants without further regulation.

Alternative No. 2.—With irrigation credit

Project	90 per cent time power	Estimated cost	Water supply for—		Irrigation credit	Remaining cost charged against power	Cost per horsepower
			Sacramento Valley	Georgetown Ridge			
	Horsepower		*Acres*	*Acres*			
Middle Fork developments	86,000	$21,250,000	[1]36,000	0	$720,000	$20,530,000	$239
Rubicon developments	99,000	20,509,000	[1]52,000	25,000	1,540,000	18,969,000	192
Silver Creek developments	79,000	19,250,000	[1]38,000	0	760,000	18,490,000	234
Total	264,000	61,009,000	126,000	25,000	3,020,000	57,989,000	220

[1] Irrigation computed on basis of controlled flow from power plants without further regulation.

Alternative No. 2 develops 11,000 more horsepower and the estimated cost per horsepower is $6 less. The total area that could be irrigated is about the same for both alternatives. This difference of 11,000 horsepower might be slightly reduced if the Rubicon water diverted to Silver Creek were dropped through a power plant at Coloma irrigation reservoir dam, although this is not planned by the city of Sacramento. The diverted Rubicon water would develop about 3,000 horsepower at this site. This gain would be partly offset by a gain to

alternative No. 2 if the Middle Fork No. 3 project were developed by the two high dams described instead of by a long conduit. The same Rubicon water through the additional head of 85 feet thus gained would develop 1,000 horsepower reducing the correction to 2,000 horsepower and reducing the difference between alternatives Nos. 1 and 2 from 11,000 to 9,000 horsepower.

59. A comparison of the Silver Creek developments alone under the two alternatives follows:

	90 per cent time power	Estimated cost	Cost per horsepower	Water supply for—		Irrigation credit	Remaining cost charged against power	Cost per horsepower
				Sacramento Valley	Georgetown Ridge			
	Horsepower			*Acres*	*Acres*			
Alternative No. 1	136,000	$32,099,000	$236	62,000	25,000	$1,740,000	$30,359,000	$223
Alternative No. 2	79,000	19,250,000	244	38,000	0	760,000	18,490,000	234

60. The second alternative will have the advantage of smaller investment. It will furnish all water needed for present municipal purposes and an irrigation district of 30,000 acres without regulation other than for power or for municipal supply and power for a city of 500,000 population at the present rate of per capita consumption. The first alternative will supply power at a slightly less unit cost when all potential power in the plan is developed and irrigation water for a utility district of 24,000 more acres than the second alternative. However, the Rubicon water could be obtained ultimately, if not diverted to Silver Creek, by projects diverting at Folsom Dam.

61. The total 90 per cent-of-time capacity of power projects in the American River Basin, development of which will be economically feasible and not incompatible with the most logical irrigation development is summarized as follows:

Stream	Horsepower
North and Middle Forks	86,000
Rubicon	99,000
Silver Creek	79,000
South Fork	64,000
Below branches	0
Total	328,000

62. Future power developments in the American River Basin and the possible storage reservoir sites on the lower reaches of the forks of the American River may ultimately furnish water during the irrigation season sufficient to irrigate an area approximately as great as 400,000 acres in the Sacramento Valley, provided power development is properly guided.

APPENDIX III

PART 1

IRRIGABLE LANDS UPON THE AMERICAN RIVER DRAINAGE AREA

By PAUL BAILEY, *Deputy Chief, Division of Engineering and Irrigation, Department of Public Works, State of California*

1. The American River in draining a part of the broad western slope of the Sierra Nevada cuts three deep canyons in its westward course. Separated by these deep-cut, precipitous canyons and their tributary gulches are many areas on the tops of the ridges having undulating and gentle slopes with favorable soil depths for agricultural purposes. The soils are primarily of weathered rock in place and there are frequent outcrops of the more resistant rocks. For the most part these are small or shattered or so separated as to little hinder agricultural operations, especially orchard plantings.

2. Except for being somewhat higher in elevation, these lands are situated similarly to the well-known fruit-growing region about Newcastle and Auburn, which occupies the territory between the North Fork of the American River and the next most northerly stream, the Bear River. Because of the transcontinental railroad passing through the Newcastle-Auburn territory, the development of these lands has preceded most of the foothill region in California. There are now some 26,000 acres under cultivation in the Newcastle-Auburn territory, and these lands are known as one of California's foremost fruit-producing regions. They are practically all irrigated.

3. The deep-cut canyons of the three forks of the American River and the absence of a transcontinental railroad have isolated the potential agricultural area of the Sierra foothills on the American River drainage. Nevertheless, there are about 3,000 acres, mostly in fruit, irrigated at the present time from the ditches of the Truckee River Power Co. The improvement of highways and motor-truck transportation is breaking the barrier of isolation that has formerly gripped these lands, and each year is now seeing a substantial increase in the occupied area.

4. For the most part, the agricultural areas have a covering of brush or small timber that costs from $25 to $75 per acre to clear by contract, but which is nowhere so heavy that it can not be handled by small operations. This circumstance, together with the rough surface naturally dividing the parcels into limited areas, makes a locality favorable for the small farmer.

5. These potential agricultural lands on the American River drainage area have been classed in the agricultural survey of California as part of the rolling plains and foothills of the Coast Range and the Sierra Nevada that circle the flat floor of the Sacramento Valley. Without continuity, the agricultural lands of the rolling plains and foothills consist, for the most part, of detached areas of low rolling hills or small valleys, or in the higher altitudes, of the flatter portions of ridges separated by the deep canyons of the major stream systems.

6. The variation in altitude is great, ranging from 100 feet at the edge of the valley floor to 2,500 or 3,000 feet on the mountain sides, with small isolated areas

as high as 4,000 feet. In general the climatic conditions below the 1,500-foot level do not vary greatly from the valley floor. The summers are long and dry. Most of the precipitation occurs between November and April. Its annual amount increases with the altitude and ranges from 20 to 45 inches, averaging 32 inches. There are warm belts lying along the foothills where the winter temperatures are notably higher than the average of the valley floor, but low temperatures are experienced in the higher altitudes. The growing season of the section as a whole is shorter than for the valley floor.

7. The variations in elevation, rainfall, and temperature make a wide range of crops possible. Citrus fruits are successfully grown throughout the thermal belt which varies in altitude but is always below the 1,000-foot contour. Apples, pears, and plums are extensively grown in the higher elevations, and peaches, cherries, prunes, vines, olives, and a great variety of fruits are grown on all but the highest elevations. Alfalfa thrives on lands of suitable surface conformation and texture. The hill lands, however, are particularly suited for fruit growing, and this will undoubtedly dominate future agricultural development.

8. Although some success has been attained in growing fruits without irrigation on the lands with heavier rainfall, the production is so increased by the application of water and the failures in seasons of little rain are so diminished that commercial fruit production requires irrigation water.

9. The agricultural lands of these foothill regions that particularly concern the proposals before the Federal Power Commission are those lying between the South and Middle Forks of the American River. There is an area of several thousand acres of agricultural land between the Middle and North Forks; however, their very great isolation, small total area, higher altitude, and undeveloped water supply make it improbable that farming operations will start there for a great many years to come, if ever. Likewise, the agricultural areas on the ridges north of the North Fork and south of the South Fork are of no concern in this report because their water supplies are already largely developed and are independent of the present proposals before the commission; but the 50,000 acres of potential agricultural lands between the South and Middle Forks have their only economic source of water supply in the headwaters of the Rubicon branch of the Middle Fork. Proposals by both the city of Sacramento and the American River Water & Power Co. are before the commission to divert these waters for other purposes.

10. The agricultural lands upon the top of the ridge between the South and Middle Forks, commonly known as the Georgetown Ridge, are from one to two thousand feet higher than the bottoms of the deep canyons in the adjacent streams. Irrigation water, therefore, has to be brought in along the top of the ridge from higher river elevations to the east. The topography of the ridge is such that favorable contours for conduit construction exist only along the northerly side. This makes the Rubicon and its branches the natural source of water supply for the Georgetown Ridge. The first branch encountered at the necessary diversion elevation is Pilot Creek, and beyond this the Little South Fork of the Rubicon and then Gerle Creek and the main stream of the Rubicon.

11. A ditch was constructed in the early mining days along this route with most of these streams as a source of supply. It is now operated by the Truckee River Power Co. and extends into all the main sections of the agricultural areas on the ridge. A storage reservoir of 8,000 acre-feet capacity has been constructed at Loon Lake, elevation 6,500, to supplement the low-water stream flow with water from storage. This water is carried partly by ditch into the headwaters of Pilot Creek. It is diverted from Pilot Creek for irrigation at about elevation 3,700. There is physical opportunity to pass this water through power drops before it is diverted for irrigation at elevation 3,700, but such an operation would

be economically feasible for approximately the full drop only in combination with a power project on the Rubicon.

12. An examination of the soils and agricultural possibilites of the Georgetown Ridge was made for the information of the Federal Power Commission through cooperation with the University of California. The joint report of Charles F. Shaw, professor of soil technology, and Prof. W. L. Howard, chief of the division of pomology, is attached hereto. It concludes as follows:

Considering the soils of this region as a whole, they appear to be of reasonably good quality, fair depth, and to be fairly well suited to the production of crops, particularly to pears and perhaps other deciduous fruits. Their development appears to have been retarded by the difficulties of transportation and by the mining interests of the people of this region. They are well suited to agricultural use and should in the future develop into an important fruit-producing region.

13. From data collected during the water resources investigation of 1923,[1] it is estimated that of the 50,000 acres of agricultural lands on the Georgetown Ridge not more than 25,000 acres will require irrigation water because of the considerable waste land due to the broken topography. The water needs will average about 1.5 acre-feet per acre on the land, or about 2 acre-feet per acre measured at the point of diversion. The ultimate required supply will therefore approximate 50,000 acre-feet annually. The proportion of this diverted during the midsummer months will be greater in this territory than in most irrigated sections because of the probable predominance of fruits that mature later in the season than general farm crops. Also, the greater winter and spring rainfall in the higher altitudes tends to defer the principal use of water until later in the season. For these reasons it is estimated that 50 per cent of the ultimate seasonal use will be diverted during the months of July and August. This will require a maximum diversion rate of 208 second-feet. A small amount of water will undoubtedly be required for domestic purposes during the winter months, as the ditch at present and for some time into the future will probably afford the cheapest and best domestic supply to the towns and villages along the ridge. The percentage of the ultimate annual use that will be diverted in each month is estimated as follows:

	Per cent of annual use
January	0.5
February	.5
March	1
April	1
May	10
June	17
July	25
August	25
September	15
October	4
November	.5
December	.5

14. In diverting water at elevation 3,700 to irrigate the Georgetown Ridge there is a loss of possible power development with this water between elevation 3,700 and the valley floor. However, the Sacramento Valley proper does not need this water for its complete irrigation,[2] nor will its diversion make power projects on the Middle Fork below elevation 3,700 unduly expensive. It is believed that the power that might be developed by dropping this water 3,500 feet to the Sacramento Valley floor instead of diverting it for irrigation at elevation 3,700,

[1] Bulletin No. 6, "Irrigation Requirements of California Lands," Division of Engineering and Irrigation, State Department of Public Works.

[2] See Bulletin No. 4, "Water Resources of California," Division of Engineering and Irrigation, State Department of Public Works.

no matter in what industry or public convenience the power may be used, can never approach in value to the State that of the 25,000 acres of potential fruit lands on the Georgetown Ridge.

15. It is therefore recommended to the California Power Board, in order to promote the greatest use of the water resources of the State, that the foregoing amounts of water be reserved on the Rubicon for the irrigation of the Georgetown Ridge and that, so far as may become possible, these waters be developed for irrigation in combination with a power project on the Rubicon.

PART 2

EXAMINATION OF THE SOILS AND AGRICULTURAL POSSIBILITIES OF A PORTION OF EL DORADO COUNTY

BY CHARLES F. SHAW, *Professor of Soil Technology*, and W. L. HOWARD, *Chief of the Division of Pomology, University of California*

16. The portion of Eldorado County covered in this examination lies between the South and the Middle Forks of the American River and extends from Georgetown and Kelsey on the east to Cool and Pilot Hill on the west. This area lies east and southeast of Auburn and north and northwest of Placerville, being readily accessible from each of these towns. In elevation it ranges from about 1,200 feet in the vicinity of Pilot Hill to about 2,500 feet along the upper or eastern border. The region is marked by numerous steep-sided valleys, some approaching canyons in character, and by irregular ridges frequently with steep and abrupt slopes. There is a considerable area, however, with sufficiently smooth topography for agricultural use, much of it being commanded by irrigation canals and with slopes of low enough grade and sufficiently smooth contour to permit of ready irrigation. The total area of agricultural land was not considered in this examination, but rather the character of the soil and its possibility of agricultural use.

17. In general the soils are medium heavy in texture, ranging from a loam to clay loams and clays. The larger part of the agricultural land appears to consist of soils of the Aiken series—red soils formed by residual weathering of lavas, tuffs, and breccias. The soils are quite irregular in depth, with many shallow spots and patches of rock outcrop. In general the depth is sufficient to give good opportunity for plant growth, and the proportion of shallow soil in most locations is not so high as to constitute a very serious factor when considered from the standpoint of tillage operations and the establishment of a uniform stand of crop over the fields. These soils can be compared to the red soils from lava rocks found on the ridges to the north and the northeast of Auburn in Placer County, in the eastern part of Nevada County, particularly between Chicago Park and Grass Valley, and in the foothill regions of Butte County in the vicinity of Wyandotte and Paradise. In these places they have given good results with deciduous fruits, and the evidence of the several pear orchards noted during this examination indicates that they would here produce deciduous fruits suited to the local climatic conditions.

18. There is a considerable area of soil derived from the slates and shales. These soils generally appear to be rather shallower than the soils of the Aiken series, but the underlying rock is usually considerably broken and shattered, affording a possible opportunity for penetration of roots deeper than the true soil. The soils from the slates and shales will probably correlate with soils of the Sites and Mariposa series. These have not been extensively mapped elsewhere in the State and it is impossible to make a direct comparison of their value. It is quite probable that returns will be somewhat less than those from

the soils of the Aiken series and that the drainage conditions will be more difficult, particularly on the smoother slopes. They should make fairly good agricultural soils, and where of sufficient depth, with good drainage, may easily be made to produce as well as the soils of the Aiken series.

19. A relatively small area of soils derived from granitic rocks was observed. These appear to belong in the Sierra and Holland series, the former being red and the latter brown in color. Here, again, there appears to be a considerable variation in the depth of the soil with many spots where the soils were very shallow or where rock outcrops occurred. The soils of the Sierra and Holland series are among the best of the residual soils in the State, giving good results with the various fruit crops that are suited to the climate in which they occur. In this case they can be directly compared with the soils at similar elevations in the Auburn-Newcastle district. They should prove well suited to the production of fruits, vegetables, and field crops.

20. Considering the soils of this region as a whole, they appear to be of reasonably good quality, fair depth, and to be fairly well suited to the production of crops, particularly to pears and perhaps other deciduous fruits. Their development appears to have been retarded by the difficulties of transportation and by the mining interests of the people of this region. They are well suited to agricultural use and should in the future develop into an important fruit-producing region.

APPENDIX IV

INDUSTRIAL USES, NAVIGATION AND FLOOD CONTROL

By U. S. GRANT, 3d, *Major, Corps of Engineers, United States Army, Chairman, California Débris Commission*

INDUSTRIAL USES—HYDRAULIC MINING

1. In the history of California the American River bears the proud distinction of having had the first discovery of gold made on its banks at Marshall's mill, near the present Coloma, on January 24, 1848. During the years 1865 to 1880, when hydraulic mining was at its height, the American River Basin was the scene of very extensive operations. In the latest survey (Grove Karl Gilbert, 1909, see U. S. G. S. Professional Paper 105, 1917, p. 43) the total amount of material moved in this basin was estimated at 257,000,000 cubic yards, being second on the list of California rivers after the Yuba with 684,000,000 cubic yards, the Bear being third on the list with 254,000,000 cubic yards.

2. After Judge Sawyer's decision in 1884, by which the right of injured landowners downstream to enjoin placer mining upstream from them was established, there was a decrease in hydraulic mining, and there has been no appreciable revival since. At present there are no hydraulic-mining operations of any size in the American River Basin. The reasons for so little mining by the hydraulic process at the present time are:

(1) Exhaustion of the most remunerative placer deposits.

(2) The cost of providing storage for the mine tailings liberated, to comply with the Federal California Débris Commission act of March 1, 1893.

(3) Difficulty in obtaining the capital required for operations on a scale large enough to be profitable.

(4) The high cost of labor.

3. The total value of gold mining in this basin during the calendar year 1922 is reported by the United States Geological Survey to have been:

Quartz mines	$66,452
Placer mines	27,088
Dredging	1,370,572
Drift and other operations	50,464
Aggregate	1,514,576

4. It appears that the contemplated projects in the American River Basin can not have a harmful effect upon mining interests and may ultimately benefit them. The storage of water in mountain reservoirs will make an ampler supply available for mining, if its value for this purpose should at any time in the future exceed its value for power or irrigation. The construction of dams in the lower reaches of the rivers will stop the flow of mining débris into the navigable channels below and permit mining operations on a small scale at costs for storage much lower than those for which individual operators can obtain the required storage space by individual works.

5. As in the case of hydraulic mining, it does not appear that the proposed projects will harmfully affect gold dredging or quartz-mining operations. In

fact, these should ultimately benefit from increased water supply and reduced cost of electric power.

6. There appear to be no other industrial uses of American River water, which will be affected by the development of this stream and its tributaries for power and irrigation.

NAVIGATION

7. There is practically no navigation upon the American River itself or on any of its tributaries. However, this stream emptying into the Sacramento River, just above the city of Sacramento, forms one of the major tributaries of the latter on which navigation is of considerable importance, having comprised 93,903 passengers during the calender year 1922, and 1,292,223 tons of freight valued at $60,614,344. Freight tonnage has been as high as 1,666,025 tons (in 1919) and it reached a maximum value of $113,991,123 in 1918. Passenger traffic attained a maximum of 212,114 passengers in 1913. Most of the waterborne commerce is carried on the section of the Sacramento River between its mouth and the city of Sacramento—that is, below its confluence with the American River.

8. There has been a very great increase in farm-land values and value of the crops produced in the Sacramento Valley in the last 15 years. This increase is largely attributable to the change from dry farming to irrigated agriculture. The most economical way of obtaining water for irrigation has usually been by direct diversion from the rivers, either by a diversion dam or by pumping directly out of the stream, and delivery of water by gravity through suitable systems of canals. The extent to which irrigation by direct diversion has already been carried has so reduced the amount of water flowing in the navigable sections of the Sacramento River as to make navigation precarious during the low-water season and actually to interrupt navigation for periods of several weeks in years of extreme water shortage.

9. The effect on navigation of water shortage in the Sacramento River due to direct diversions for irrigation is most pronounced in the months of July, August, and September and in the section of the river lying between the city of Sacramento and Colusa. The effect of tides is felt up to the city of Sacramento, and the shortage of water below this city impedes navigation only to a slight extent as far down as Isleton. But there is a pronounced tendency for salt water to work its way up from San Francisco Bay through Suisun Bay in the many channels of the delta region, when the flow of fresh water by the city of Sacramento is reduced below 4,000 to 3,500 second-feet. It is therefore vital for the preservation of large irrigation projects in the Sacramento and San Joaquin delta that the fresh-water flow in the Sacramento River should not fall below this minimum, the flow of the San Joaquin being inadequate to help materially in keeping the salt water out of the delta. It is therefore necessary to consider the effect that any projects proposed for the American River will have upon the navigability of the Sacramento and upon the allied and concurrent interests of long-established irrigation projects in the delta. The aggregate value of the agricultural products grown in the four delta counties (Contra Costa, San Joaquin, Solano, and Sacramento) reached $100,353,600 in 1920, but the portion grown in the delta lands themselves, subject to injury by the rise of salt water when the fresh water supply falls too low, probably did not exceed $35,730,800.

10. In general it may be said that the low-water flow of the streams will be definitely decreased by direct diversion for irrigation, but that it will be increased by any project which stores water in the high-water season and releases it for either power or irrigation in the low-water season. The water released from

storage for production of hydroelectric power, unless intercepted further downstream and used for irrigation, manifestly is a direct and clear gain for the total stream flow at the time the power is produced. Of the water spread over the land for irrigation a certain proportion returns to the stream below by direct drainage and a smaller part by seepage, so that even the water held over in storage from the high-water season and used for irrigation during the low-water season will in part return to the river after a short period of delay and will thereby to some extent increase the low-water flow in the stream. The amount of irrigation water which returns to the stream in time to be of use during the low-water season is dependant upon so many changing local conditions that it is not practicable to determine exactly what coefficient to use in figuring the return for any particular project, but it is thought that 15 per cent is a reasonable assumption for the foothills and the higher parts of the Sacramento Valley.

11. The relation of the present low-water flow in the various branches and tributaries of the American River, on which the projects now under consideration are to be built, to the regulated flow which it is expected these projects will produce by storage is shown in the following tabulations:

1. *American River Water and Power Co.*

NORTH AND MIDDLE FORKS OF AMERICAN RIVER

	1911		1912		Remarks
	August	September	August	September	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	
Regulated flow from project	182	207	201	176	French Meadows site. From Table 10, Kramer report on project 334.
Natural flow without project	33	11	18	22	At French Meadows, Kramer report.
Resultant gain to river	149	196	183	154	

2. *Truckee River Power Co.*

RUBICON RIVER

	1911		1912		Remarks
	August	September	August	September	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	
Regulated flow from project	408	340	336	337	From Table 8, column 33, American River report.
Proposed for irrigation	208	125	208	125	From Table 8, column 29, American River report
Return from irrigation	31	19	31	19	15 per cent of water used for irrigation.
Resulting river run-off	439	359	367	356	Line 1 plus line 3.
Natural flow without project	141	54	82	105	Quintette gauge on Rubicon plus Pilot Creek.
Resultant gain to river	298	305	285	251	

3. *City of Sacramento*

SILVER CREEK

	1911		1912		Remarks
	August	September	August	September	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	
Regulated flow from project	314	308	302	299	From Table 10, American River report, column 25 minus column 13.
Proposed for city use	150	150	150	150	For population of 400,000 estimated for 1950 from report by Albert Given for city of Sacramento, p. 40.
Proposed for irrigation	164	158	152	149	
Return from irrigation and city	100	99	98	97	50 per cent from city use and 15 per cent from irrigation.
Natural flow without project	77	48	68	74	At mouth of Silver Creek.
Resultant gain to river	23	51	30	23	

4. *Western States Gas and Electric Co.*

SOUTH FORK OF AMERICAN RIVER

	1911		1912		Remarks
	August	September	August	September	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	
Regulated flow from project	180	180	180	180	American River report, Appendix II, paragraph 48.
Natural flow without project	204	70	70	73	At junction with Silver Creek.
Resultant gain to river	0	110	110	107	

12. From the above, under the conservative assumption that there will be a return of about 15 per cent of the water used for irrigation and 50 per cent of that used for domestic purposes, it appears that the aggregate gain in the low-water flow in the American River below Folsom that would result from a full utilization of all the storage proposed would be approximately 675 second-feet as compared with the present low-water flow, which has been 100 second-feet at Fairoaks, or less, during five different years between 1905 and 1918. Of course, if any large part of this water is used for irrigation in the bottom lands of the Sacramento Valley the amount reaching the Sacramento River will be decreased by somewhere between 80 and 90 per cent of the water so used.

13. Since the American River joins the Sacramento River at the city of Sacramento, the gain to be expected from those projects will not benefit navigation over the most critical stretch, namely, from Sacramento to Vernon, but it will help in maintaining adequate depths over the stretch immediately below Sacramento, where navigation is most important in volume and value, and it will enhance the amount of fresh water delivered to the irrigation projects on the lower river.

14. If the project of the American River Water & Power Co. should finally be worked out so as to use for a domestic and municipal water supply of Oakland and other San Francisco Bay cities any large part of the water stored, the amount of water so delivered directly through pressure conduits would, of course, never reach the Sacramento River, and the increase in low-water flow indicated by the above tables would have to be correspondingly decreased. In conclusion,

it may therefore be said that the proposed projects may all be expected to increase the flow of fresh water in the Sacramento River below the American to an extent depending upon the use to which the stored water is put, thereby offering some promise of improvement for navigation below the city of Sacramento and an appreciable aid to solving the irrigation problems of the delta region.

FLOOD CONTROL

15. A very complete project for the protection of the Sacramento Valley against floods in its rivers was adopted by the act of March 1, 1917. This project is now in course of execution, the cost being carried by equal contributions of the United States and the State of California for the channel work and weirs; while the cost of levees, rights of way, by-passes and auxiliary works are paid by assessments on the lands benefited. This project provides for an anticipated run-off of 120,000 second-feet in the American River, but there are indications that a peak run-off approximating 185,000 second-feet may have been reached in the past. The safe bankful run-off approximates 45,000 second-feet below Folsom.

16. While the aggregate reservoir capacity which it is expected to develop in the American River Basin by the contemplated projects seems large (404,100 acre-feet), nevertheless the reservoirs would not be so located as to be very effective for flood storage. High-water measurements on the upper tributaries of the American River during times of extremely high floods are not of record and no full examination of this question, nor reliable estimate of the reduction in flood heights that might be obtained by operation of the reservoirs for flood control, is possible. Study of the rather limited data available leads to the conclusion that even under the most favorable circumstances these reservoirs would not effect a reduction of more than 12 per cent in such a flood as that of March 18-22, 1907.

17. It is evident that the value of the contemplated reservoirs for flood control is much less than their estimated cost and that flood protection of the valley lands can be obtained much more cheaply by completion of the approved flood-control project.

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